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# PRIZE ESSAYS

Issued in connection with

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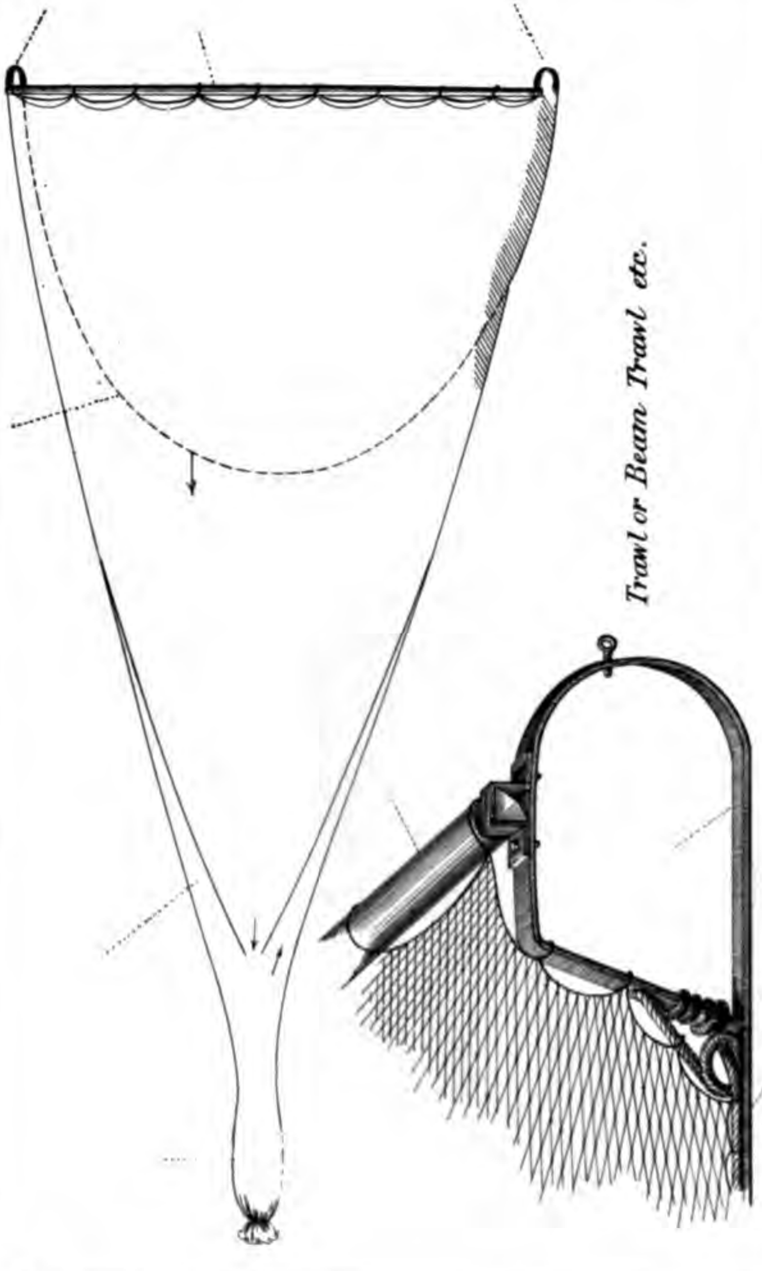
## PART III.

LONDON

1883

X.-9.

*Frontispiece*



*Trawl or Beam Trawl etc.*

*International Fisheries Exhibition*

LONDON, 1883

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THE

# FISHERIES EXHIBITION LITERATURE.

## *VOLUME X.*

### PRIZE ESSAYS—PART III.

THE NATURAL HISTORY OF COMMERCIAL SEA FISHES OF GREAT BRITAIN AND IRELAND.

IMPROVED FACILITIES FOR THE CAPTURE, ECONOMIC TRANSMISSION AND DISTRIBUTION OF SEA FISHES.

A CENTRAL WHOLESALE FISH MARKET FOR LONDON.

THE BEST APPLIANCES AND METHODS OF BREAKING THE FORCE OF THE SEA AT THE ENTRANCE TO HARBOURS AND ELSEWHERE.

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# PRIZE ESSAYS—PART III.

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# THE NATURAL HISTORY

OF

# COMMERCIAL SEA FISHES OF GREAT BRITAIN AND IRELAND,

WITH

## SPECIAL REFERENCE TO SUCH PARTS OF THEIR NATURAL HISTORY AS BEAR UPON THEIR PRODUCTION AND COMMERCIAL USE.

---

> “*We will discourse about fish.*”
> ‘Ημεῖς μὲν ἰχθυολογήσομεν. (ATHENÆUS, *Deipnosoph.* 308 *d.*)

[REV. W. HOUGHTON, M.A., F.L.S.]

# THE NATURAL HISTORY
OF
# COMMERCIAL SEA FISHES
OF
# GREAT BRITAIN AND IRELAND.

## INTRODUCTION.

THE different topics arising out of a consideration of the various sea fishes which are found in the waters of the coasts of Great Britain and Ireland will be found treated of more or less fully according to their interest and importance, under the respective headings relating to the various species of food fishes which have a commercial value. It is obvious that in a subject embracing a variety of considerations, such as pertain to their natural history, food, habits, and localities of fishes, each fish requires a separate notice.

It seems desirable, however, in this introductory part of the subject to say a few words on the general questions in a more consecutive manner, and to place before the reader such points in the Natural History of our Commercial Sea Fishes as may seem to the writer of this essay to be most desirable to bring forward.

We may approach the subject by dividing it into the two following heads:—

1. Fish as a class of vertebrate animals.
2. Sea fishes in their relation to man.

Interesting questions naturally arise in connection with these two heads, some of the most important of which will be discussed.

1. With respect to the first head it is evident that there are various zoological questions of importance which bear directly or indirectly upon the second. To some of these zoological questions prominent attention is given; even apparently remote causes may produce important direct effects.

On the first general division, fish as a class of vertebrate animals, it will not be necessary to say very much.

*Form of body.*—The form of the body is subject to great variety, to a greater extent than occurs in other classes of vertebrates; it may be nearly globose, or elongated, or wedge-shaped, or compressed, or vertically depressed, as in the tetrodon, eel, mackerel, dorey, sole and skate, respectively. One of the most common forms is that of a simple equally formed wedge, compressed or slightly rounded, well fitted for cleaving the water, of which the mackerel is one of the most familiar instances, a fish, as Yarrell has well observed, which exhibits the highest degree of elegance in shape, and when recently taken from the water so rich and so varied in colour as to be fairly entitled to be considered one of the most beautiful among British fishes. The form of the body must always be noticed, as of course much relating to the habits and modes of life depend upon it. Similarity of form, though frequent in the same group of fishes, by no means indicates, as Dr. Günther remarks, natural affinity.

*Scales.*—The body is usually covered with scales, but some fish are destitute of them; or it is provided with scales of various forms and sizes; the head and fins are generally destitute of scales to any extent. As the forms of scales are generally taken into account in the description of a fish, it will be well briefly to mention them. Scales are *cycloid* (κύκλος, "a circle") when they have an entire not denticulated posterior margin and a concentric striation. Scales are called *ctenoid* (κτενός, gen. c. of κτείς, "a comb") when they have spinous teeth on the posterior edges of their layers, of which there are various forms. *Ganoid* scales (γάνος, "brightness," "polish") are hard and bony, and covered with a layer of enamel, "rhombic or quadrangular, rarely rounded and imbricate, arranged in oblique rows, those of one row being linked together by an articulary process." This kind of scale occurs only among recent fishes (common in fossil), in the genera *Lepidosteus* and *Polypterus;* not represented in the British fauna.

In some fishes, as in sharks and other kinds, there are no fine scales, but bony papillæ of the skin (shagreen). This form was called *placoid* (πλάξ, πλακος "a flat plate"), a word which expresses only one form of papilla, and which had better become obsolete.

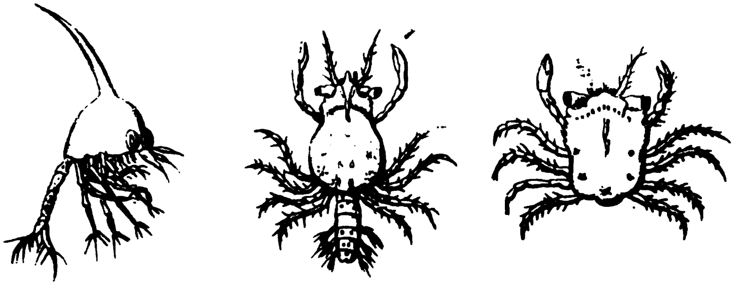
*Lateral line.*—In the description of the various fishes which have come under our consideration, mention is frequently made of the *lateral line;* this line runs along each side of the fish's body in the osseous kinds; it consists of a series of scales, each of which has a perforating duct at its base, and an outer opening, either simple or branched. These ducts are usually filled with mucus which serves to lubricate the whole body of the fish and to expedite its movements through the water. "The scales, their structure, number, and arrangement, are an important character for the determination of fishes; in most scaly fishes they are arranged in oblique transverse series; and as the number of scales in the lateral line generally corresponds to the number of transverse series, it is usual to count the scales in that line. To ascertain the number of longitudinal series of scales, the scales are counted in one of the transverse series, generally in that running from the commencement of the dorsal fin, or the middle of the back to the lateral line, and from the lateral line down to the vent or ventral fin, or middle of the abdomen." (Günther, 'Study of Fishes,' p. 49.)

*Fins.*—These important organs are divided into *vertical* or *unpaired*, and *horizontal* or *paired;* any of them may be present or absent; they furnish guides for distinguishing orders, families and genera, in determining the affinities of fishes. The fin-membranes are usually supported by slender bony processes called rays; they may be either simple, spinous, simple articulated soft, or branched soft rays.

The names of the different fins are derived from the part of the body to which they are attached; thus we have the dorsal, pectoral, ventral, anal, and caudal, all of which so far speak for themselves. The character of the dorsal fin has served to form the two large types of *Acanthopterygian*, "spiny-rayed," and *Malacopterygian*, "soft-rayed" fishes. In the former some of the rays are simple and without transverse joints, and can be depressed or erected at the will of the fish; in the latter all the rays are jointed. The ventral fins are homologous with the hinder limbs in other animals; their situation on the abdominal surface varies according to the different groups; if they are situated behind the pectorals, they are said to be *abdominal;* if below them, *thoracic;* if in front of them, they are said to be *jugular*. In some fishes, as in the Gobies, these ventral fins form by their coalescence a kind of suctorial disc. The numbers of the spines and rays, especially in the ventrals, are of great importance for the determination of the species; according to their number in the ventral fins "the Acanthopterygian affinities of a fish can nearly always be determined."

X.- 9.

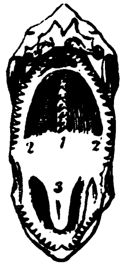
Plate I.



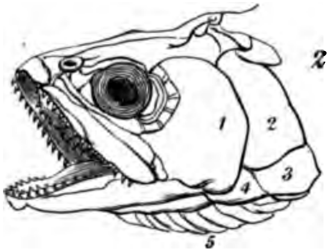
Different Stages of Crab larva
(Magnified)

Hyperia Galbus
(Herring food)
nat. size

Lerneonema Spratti
Epizoon on the Sprat



1.



2.

1 Front view of the mouth of a trout (1) Vomerine teeth (2) Palatine (3) Tongue teeth

2. Side view of Trout's Head
(1) Preoperculum (2) Operculum
(3) Suboperculum (4) Interoperculum (5) Branchiostegal Rays

The chief organ of motion in fishes is the tail with the caudal fin; this can readily be observed while watching the motions of fishes in an aquarium. The function of the pectoral fins serves more for steering and balancing than for propelling in most fishes; nevertheless in some fishes the tail is not the chief propelling power, as in the fifteen-spined stickleback, whose rapid short darts through the water are caused by the quick movements of the pectoral fins, the action of which either in propelling or steering or reversing motions is beautiful to behold. If the fins of a fish be cut off, and it be returned to the water, it will float with the belly upwards, showing that the chief function of the paired fins is to balance the fish in the water.

*The gill-covers or opercula.*—The operculum often affords important external characters. It consists of four parts in most fishes, viz. (1) the pre-operculum, (2) the operculum, (3) the sub-operculum, and (4) the inter-operculum. All these bones, the forms of which may be readily seen in any boiled fish when they separate, are more or less lamellar, and cover the cavity containing the gills of the fish, hence they are collectively called *opercles* or gill-covers. (Plate I. Fig. 2.)

*Gill-opening* is the slit behind or below the head, by means of which the water taken into the mouth for the purpose of respiration is again expelled. The form and structure of the gill-cover vary.

*Branchiostegals.*—Below the gill-cover is a membranous part supported by one or many bony rays; these are called the branchiostegals; the bony supports are known as the branchiostegal rays and in the description of a fish it is usual to count the number of rays. (Plate I. Fig. 2.) In the rays and sharks the passages for the exit of the respired water are different from those of bony fishes; they consist of fine slits situated on the sides of the head in the sharks, dog-fish, &c.,

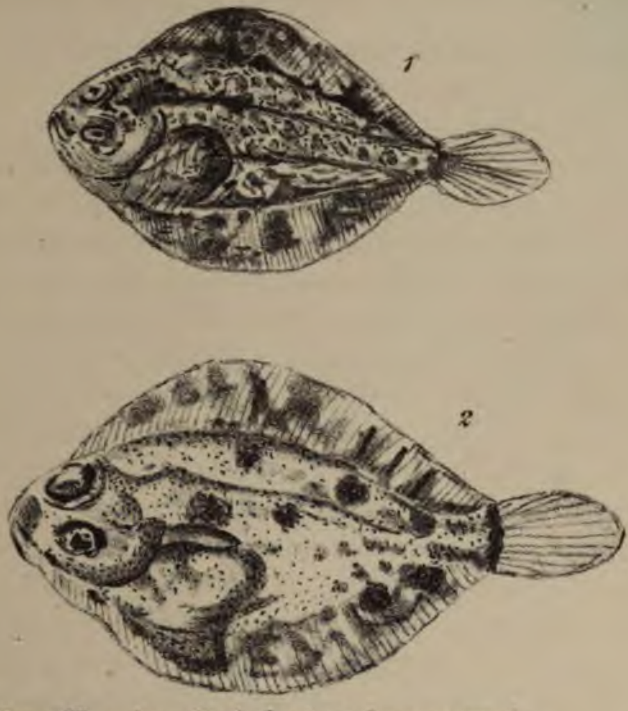
and on the under side of the head in the rays or skates; other differences or modifications need not be mentioned here.

*Gills or branchiæ.*—These organs, whose function is that of respiration, "consist essentially of folds of the mucous membrane of the gill-cavity in which the capillary vessels are distributed. In all adult fishes the gills are lodged in a cavity." In most bony fishes there are four complete gills supported on branchial arches, but frequently "the fourth arch is provided with a uniserial gill only, or is even entirely gill-less." On the concave side of these branchial arches in most bony fishes there is to be seen a series of stiff filaments, or horny protuberances of various forms, called *gill-rakers.* (Plate II. Fig. 3.)

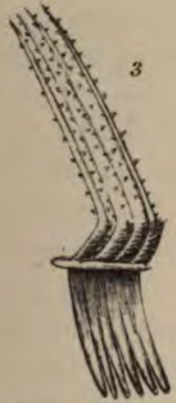
*Gill-rakers.*—When well developed, as in the herring, shad and other fishes, their function is subservient to a means of catching any particles which the water received into the mouth brings with it. Herrings use their gill-rakers in collecting the small crustacean food from the water, and when a sufficient quantity is obtained the lot is swallowed. In many fishes these gill-rakers can have no sieve-like function of any kind, as they consist of mere rough tubercles, as in the perch.

*Pseudo-branchiæ.*—In the description of the fishes in this essay mention is made of the presence or absence of *pseudo-branchiæ.* "They are the remains of an anterior gill which had respiratory functions during the embryonic life of the individuals. By a change in the circulatory system these organs have lost those functions, and appear in the adult fish as *retia mirabilia,* as they receive oxygenised blood, which after having passed through their capillary system is carried to other parts of the head" (Günther).

Connected with the respiratory organs of fishes are questions which have a practical importance in the matter



*1. Young Flounder, fig. 1. showing colors assumed when the fish is placed upon a dark mud coloured ground.*
*2. The same fish; somewhat enlarged, showing the colours assumed when placed upon a yellowish sandy soil (after Agassiz.)*



*Portion of Gills & Gill Rakers of the Herring*
*U. S. Commissioners Report. p. 537.*

of safely conveying living fish any distance, from one locality to another. Some fishes can endure for a long time out of water; others die soon after they are removed from it. "When fishes confined in a limited quantity of water," as Yarrell well observes, "are prevented by any mechanical contrivance from taking in atmospheric air at the surface, they die much sooner than others that are permitted to do so. The consumption of oxygen is, however, small, and the temperature of the body of fishes that swim near the bottom, and are known to possess but a low degree of respiration, is seldom more than two or three degrees higher than the temperature of the water at its surface. Dr. John Davy, however, in a paper read before the Royal Society of London in 1835, on the temperature of some fishes allied to the mackerel, all of which are surface swimmers with a high degree of respiration, observed that the bonito had a temperature of 90 degrees of Fahr. when the surrounding medium was 80° 5′, and that it therefore constituted an exception to the generally received rule, that fishes are universally cold blooded. Physiologists have shown that the quantity of respiration is inversely as the degree of muscular irritability. It may be considered a law that those fish which swim near the surface of the water have a high standard of respiration, great necessity for oxygen, die soon, almost immediately when taken out of the water [but see under Herring], and have flesh prone to rapid decomposition. Mackerel, salmon, trout, herrings are examples. On the contrary, those fish that live near the bottom of the water have a low standard of respiration, a high degree of muscular irritability, and less necessity for oxygen; they sustain life long after they are taken out of the water, and their flesh remains good for several days; carp, tench, eel, skate and all the flat fish may be quoted" ('British Fishes,' Introd

p. xv). With regard to tenacity of life or the power of adapting themselves to conditions different from their usual ones, or their ability to endure heat or cold, fishes differ considerably. Whereas several freshwater fishes are readily acclimatised, sea fishes as a rule are very sensitive to changes in the temperature and will seldom bear transportation from one climate to another. Sudden removals from salt water to fresh, or *vice versâ*, do not affect some fishes in the smallest degree. I have taken a stickleback out of a fresh ditch and placed it immediately into an aquarium of salt water, and beyond a little difficulty in accommodating itself to the different density of the salt water the fish seemed perfectly happy.

*Eyes.*—The eyes of fishes are, generally speaking, of considerable size compared with other vertebrates; the crystalline lens is spherical and well adapted for vision at short or moderate distances. The sight is eminently acute in most fishes that do not live at great depths. Every angler knows how rapidly the trout darts away when a moving object shows itself, and trawlers and drift-net fishermen know well that their chances of taking a quantity of fish when the water is clear are much less than when it is muddy. The position of the eyes on the head varies in various fishes. Generally they are placed on the flattened side of the head, they are then said to be *lateral;* in some fishes they have an upward aspect, as in the weavers, and the *Uranoscopus* ("heaven gazer"); in a few they have a downward aspect. In the flat fishes (*Pleuronectidæ*) both eyes are on the same side of the head in the adult; the same is the case in the rays, &c. The researches connected with the *Challenger* Expedition have brought to light several kinds of sea fishes which live at enormous depths where no light can penetrate; in such the eyes are wanting, or rudimentary, as in the case of certain fish which inhabit dark caves; if, however, the fishes live at depths not entirely shut off from the light, then the visual organ is of extraordinary size, so as to catch the few faint rays of light that may reach those depths; or large eyes may bespeak nocturnal habits. Some fishes which possess both eyes on the upper side of the head can raise or depress them at will. A long period of domestication may result in the alteration of form of a fish's eyes; thus we have a monstrous variety of the gold fish (*Cyprinus auratus*), with large protruding eyes and trilobed tail-fin; sometimes to be seen in our aquaria, and called "telescope fish." But the most curious, and interesting, perhaps, in this respect are the *Pleuronectidæ.* The whole subject of the development of certain of the flat fishes, as the flounder, has been most elaborately and carefully worked out a few years ago (1878) by Alexander Agassiz, and his researches on the "Development of the Flounder" are full of most instructive matter.*

*Eyes of flat fishes.*—The development of the flat fishes (*Pleuronectidæ*) is certainly one of the most curious phenomena among the whole class of PISCES. The adults, as is well known, rest on one or other of their sides, sometimes on the right, as in the turbot (*Rhombus*), flounder (*Pleuronectes*); sometimes on the left, as in the holibut (*Hippoglossos*) and sole (*Solea*). They cannot retain their bodies in a vertical position like other fishes. That side which is turned towards the bottom is nearly always colourless; the upper side is coloured. Both eyes are always on the coloured side in all normal specimens; but in the *young stage* of these flat fishes the eyes are arranged symmetrically, one on each side of the head, and they swim vertically like other fishes. The young flounder has been made the special subject of investigation by Dr. Alexander Agassiz and other naturalists before him. Agassiz has a very valuable paper "On the Young Stages of Osseous Fishes and the Development of the Flounder," in the Proceedings of the American Academy of Arts and Sciences, vol. xiv. 8 plates. Cambridge, U.S., 1878. It appears that the young flounder—and what is true of the flounder is most probably true of the *Pleuronectidæ* in general—after its escape from the egg presents no special points of difference from the embryoes of other bony fishes in a similar stage of growth. Not till the young flounders are ⅜ of an inch in length can the first slight difference in the position of the two eyes, when seen from above, be perceived, the left being somewhat in advance of the other. *Both* sides are then coloured, and, like other bony fishes, exhibit in their young state an extraordinary development of the chromatophores or pigment cells. Eventually they lie down on the left side, the colour vanishes and the under surface is white. But it appears that for some time after they have assumed the characters of the adult they frequently swim *vertically*. "All swim near the surface when they come to feed while the water is smooth, about 10 o'clock in the morning, on bright sunny days, when they devour swarms of the embryo crustaceans." When disturbed they sink into deeper water. "Only when the young fishes are old enough to be recognised as the young of their tribes do they venture to join them in their ordinary haunts." One of the eyes, that on the resting side, has actually made a passage from one side of the head to the other; either the eye has, independently of the surrounding organs, pushed its way through the soft yielding cartilaginous bones, or the whole of the under side of the fore-part of the head has accompanied the eye in its migration. To what singular operating cause can such a change of position in the eyes be assigned?

---

* "On the Young Stages of Osseous Fishes." ii. Development of the Flounders. Proceedings of the American Academy of Arts and Sciences, with 8 plates. Cambridge, June, 1878.

One thing seems pretty clear, that the transit of the eye of the one side to the other results from the habit of the young flounder to rest on one side. The eye of that side would from want of use either become aborted, or go somewhere else if it were able. It *is* able to do this; so we come primarily to the question, why does the young flounder lie down on one side and not rest vertically as other osseous fishes?

Thanks to the philosophical reasoning and observations of one of the greatest and noblest men that this or any other age or country has ever produced, the late lamented Charles Darwin, naturalists are now able to look in the right quarter for explanation of phenomena which before Darwin's time lacked an Œdipus to unravel them. Let us consider the phenomenon of *Coloration.*—It is a well-known fact that many animals gain protection to themselves by simulating, either in form or colour or in other ways, the character of the substance on which they rest; by this means they are able to escape the notice of those animals that would prey upon them, and they can at the same time avoid observance by those animals on which they themselves feed. Now the power possessed by some fishes to assume a colour to some extent similar to that on which they rest or to which they are closely contiguous, is known almost to every angler who observes how rapidly a trout, for instance, assumes the colour of the vessel in which it is placed. The flounder varies in colour, being dark or light according to the colour of the ground. How rapidly this change of coloration by the alteration in the positions of the different pigments may take place, has been interestingly proved by Dr. Alex. Agassiz in several experiments. (Plate II. Figs. 1 and 2.) Impressions of colour received by the eye and occasioned by the reflex action of the nervous system produce movements in the chromatophores inducing changes of colour in the pigment cells. But how do we account for the disappearance of the pigment from the side on which the fish rests? Pouchet has experimentally proved that it is possible to produce a white side in trout by destroying the eye of that side. As the eye on that side no longer exists to receive impressions of colour, the chromatophores being no longer subject to the exciting stimulus of light, become atrophied and disappear, and a partial atrophy of a portion of the great sympathetic nerve takes place. To sum up these curious phenomena: the young flounder has symmetrical eyes like other fish, and swims vertically. It lies down on one side; the eye of that side having no useful function to perform passes over to the other side where it is useful. The disappearance of the eye from the side on which the fish rests has been followed by the atrophy of the pigment cells, and their disappearance is a natural result of the departure of the eye from that side; thus we have in the flounder, and probably in the *Pleuronectidæ* generally, excellent illustrations in their early lives, of ancestral form and adopted modification. I have already stated, when speaking of the turbot, that the young fry of this fish has an eye on each side of its head, and I must not repeat what I have said on that subject.

*Organs of hearing.*—Fishes possess no external organs of hearing; in most of them the internal organ consists of a vestibule which opens out into one or more cavities which contain the otoliths familiar to all eaters of cod and whiting, and three semicircular canals. In many of the bony fishes (*Teleostei*) there is a connection between this internal ear and the air-bladder. The power to hear sounds must be very limited; loud noises, however, as the report of a cannon or gun, would affect them by producing vibrations on the water, which, if the fish were near the surface, would extend their impressions to the fish by shaking the otoliths within the vestibular sacs. Direct blows on the water of course would reach them better than sounds proceeding from the air, and in some countries it is not uncommon to stun fish under the ice by a heavy blow just above where the fish lies, and thus capture it. How far it may be true that fish readily answer the sound of a bell or a whistle, and come at their master's call to feed from his hand, I know not; the tread of the foot on the bank or margin of the pond seems to me the more likely to be the summoning call than a sound proceeding from the air. How readily the water receives impressions from a blow on the adjacent bank may be witnessed by any one who will stamp but lightly on a bank, when the contiguous water will immediately exhibit little waves; this is best seen when the water has a very thin coating of ice here and there, as the water, in fact, is just freezing.

*Organs of touch.*—Fishes probably are not generally supposed to be very sensitive to touch on their scaly bodies;* but in those fishes which possess barbules which are well supplied with nerves, the sense of touch is delicate. If any one will notice the way in which a sturgeon picks up worms, how, as soon as its barbules come in contact with the food it loves, the mouth is in a second of time protruded and the worms taken into the mouth, he will appreciate the delicateness of touch that these food-indicating organs possess.

---

* Dr. Günther is doubtless correct in considering they are sensitive; "they perceive impressions even on those parts which are covered by osseous scales, in the same manner as a tortoise perceives the slightest touch of its carapace."

The three fringe-like pectoral filaments of the gurnards are strongly supplied with nerves, and any one who has noticed the use they make of these organs in locomotion in an aquarium may be well assured that they are very sensitive to touch.

*Organs of smell.*—On each side of the upper surface of the snout there are in most fishes two nostrils, more or less close together, which lead to one common canal ; but with the exception of one family (the *Myxinoids*) they do not perforate the palate. In the sharks and rays the nostrils are on the lower surface of the snout and more or less confluent. As the olfactory nerves are of large size and cover a wide surface, the sense of smell in fishes is acute ; and this is evident from the selection they make in their food. Fishermen know well that tainted bait is not so tempting as fresh bait ; a very hungry fish will not be particular, but the odour of stinking bait is repugnant to fishes generally.

*Organs of taste.*—Fishes generally have probably little if any sense of taste, if we are to judge of the way in which they bolt their food without mastication ; the *Cyprinidæ*, however, masticate their food and even bring back portions of it into the throat for trituration by the pharyngeal teeth ; they are chiefly vegetable feeders, and possibly may have some slight perception of taste on the soft cushion-like organ on the roof of the palate, which is richly supplied with nerves. Still one cannot positively affirm or deny the perception of this sense in fishes.

*Teeth.*—The teeth of fishes vary considerably ; in form they may be cylindrical or conical, pointed, straight, or curved. Some teeth are broad, and remind one of molars in the warm-blooded vertebrates ; some are like flexible bristles, when they are called *setiform* or *ciliaform ;* very fine, conical teeth arranged in a band are termed *villiform teeth,* when they are coarser or mixed with coarser teeth they are *cardiform,* when they have a flat or lower surface they are termed *molars,* if of small size *granular.*

In all fishes the teeth are constantly shed or renewed during the whole course of their life. Generally there are several teeth growing in various stages of development, and destined to replace those in use. Almost everyone is familiar with the jaws and teeth of the shark, in which the whole phalanx of numerous teeth is ever marching slowly forwards or backwards in rotatory progress over the alveolar border of the jaw, the teeth being successively cast off after having reached the outer margin and having fulfilled for a longer and shorter period this special function (see Günther, 'Study of Fishes,' pp. 126, 127).

*Digestive organs.*—Connected with the teeth of fishes are their food and digestive organs. On this subject I cannot do better than quote Dr. Günther's own words.

"Fishes are either exclusively carnivorous or herbivorous, but not a few feed on vegetable substances as well as animal, or on mud containing alimentary substance in a living or decomposing state. Generally they are very voracious, especially the carnivorous kinds, and the rule of 'eat or be eaten,' applies to them with unusual force. They are almost constantly engaged in the pursuit and capture of their prey, the degree of their power in these respects depending on the dimensions of the mouth and gullet, and the strength of the teeth and jaws. If the teeth are sharp and hooked they are capable of securing the most slender and agile animals; if this kind of teeth is combined with a wide gullet and distensible stomach, they are able to overpower and swallow other fish larger than themselves; if the teeth are broad, strong molars, they are able to crush the hardest aliments; if they are feeble, they are only serviceable in procuring some small or inert or unresisting prey. Teeth may be wanting altogether. Whatever the prey, in the majority of cases it is swallowed whole; but some of the most voracious fishes, like some sharks and *Characinidæ*, are provided with cutting teeth, which enable them to tear their prey to pieces if too large to be swallowed whole. Auxiliary organs for the purpose of overpowering their prey, which afterwards is seized or torn by the teeth, like the claws of some carnivorous mammals and birds, are not found in this class, but in a few fishes the jaws themselves are modified for that purpose. In the sword-fishes the bones of the upper jaw form a long dagger-shaped weapon with which they not only attack, but also frequently kill fishes on which they feed. The saw-fishes are armed with a similar but still more complicated weapon, the saw, which is armed on each side with large teeth implanted in deep sockets, specially adapted for killing and tearing the prey before it is seized and masticated by the small teeth within the mouth. Fishes show but little choice in the selection of their food, and some devour their own offspring indiscriminately with other fishes. Their digestive powers are strong and rapid, but subject in some degree to the temperature, which, when sinking below a certain point, lowers the vital powers of these cold-blooded animals. On the whole, marine fishes are more voracious than those inhabiting fresh waters; and whilst the latter may survive total abstinence from food for weeks or months, the marine species succumb to hunger within a few days.

*Growth.*—The growth of fishes depends greatly on the nature and supply of food, and different individuals of the same species may exhibit a great disparity in their respective dimensions. They grow less rapidly and to smaller dimensions in small ponds or shallow streams, than in large lakes or deep rivers. The young of coast fishes when driven out to sea, where they find a much smaller supply of food, remain in an undeveloped condition, assuming an hydropic appearance. The growth itself seems to continue in most fishes for a great length of time, and we scarcely set bounds to—certainly we know not with precision—the utmost range of the specific size of fishes. Even among fishes in no way remarkable for their dimensions, we sometimes meet with old individuals, favourably situated, which more or less exceed the ordinary weight and measurement of their kind. However, there are certain evidently short-lived species which attain a remarkably uniform size within a very short time; for instance, the stickleback, and many species of *Gobius* and *Clupea* ('Study of Fishes,' pp. 121–123).

*Intestinal tract*, contains four portions, œsophagus, stomach, and small and large intestine. In the descriptions of the different species, mention is made of the *pyloric appendages*. The stomach of a fish is usually of large size, and the walls are thin; sometimes, however, the walls are thick and muscular, as in the grey mullet and gillaroo trout. The stomach generally forms a curved tube, like a syphon, the descending portion is called the *cardia*, the ascending part is the *pylorus*, which is generally provided with a valve. Behind the pyloric opening of the stomach there are in many fish a number of blind tubes called the *pyloric cæca* or *appendages*, which vary in number as well as in structure; there may be only two or three of these cæca, or there may be as many as two hundred. It is supposed that these appendages perform the function of the pancreas, at any rate the smaller cæca serve as secretory organs. In many fish they are altogether absent. A pancreas, however, is found in many fishes which also possess these pyloric appendages.

*Air-bladder.*—The air-bladder, sometimes called the swim-bladder is a sac filled with gas; it is variable in form in different fishes; it extends along the back of the abdomen between the kidneys and intestinal canal; it is either closed or communicates by a duct with the œsophagus. It is compressible, and functionally serves to alter the specific gravity of the fish. In some few fishes, not British, as in *Protopterus* and *Lepidosiren*, the air-bladder is a highly complex cellular organ, which both structurally and functionally is a lung. The contained gas in most freshwater fishes consists of nitrogen with a very small quantity of oxygen and a trace of carbonic acid. In sea-fishes, especially in those living at great depths, oxygen predominates, as much as 87 per cent. having been found; the gas is secreted from the inner surface of the air-bladder. In the flat fishes (*Pleuronectidæ*) there is no air-bladder; on this account, and on account of the structure of the paired fins, they cannot swim in a vertical position, but rest and move on one side of the body only.

*Sexes and organs of reproduction.*—In all fishes there are two distinct sexes, instances of hermaphroditism are very rare. *Serranus* exhibits true hermaphroditism, other instances are regarded as abnormal individual peculiarities. There are no obvious external signs by which the sexes can be distinguished, except in the rays and sharks, where the male organs are to be seen in the so-called "Claspers." Fishes as a rule produce eggs, a few, however, are viviparous. The "hard roe" is the mass of eggs of the female, the "soft" is the milt of the male. In some families the ovaries have no closed covering and are without oviducts, as in the

*Salmonidæ*, *Murænidæ*, etc. The ova when ripe, drop into the abdominal cavity and are expelled by the genital opening; but in most bony fishes the ovaries are closed sacs continued into oviducts. Those fish which have no oviduct deposit their eggs separated one from another; those with an oviduct in many instances have their eggs enveloped in a glutinous substance, which swell in the water and form lumps or cords. In some of the carps, as in *Rhodeus*, the oviduct is at spawning time prolonged into a long tube by means of which the female deposits her eggs within the shells of living bivalves.

*Forms of eggs.*—The eggs of nearly all fishes are globular and soft shelled; this is the case with nearly all bony fishes (*Teleosteans*); those of the cartilaginous fishes, as sharks and rays, are curiously shaped quadrangular bodies, whose outer integument consists of a leathery tough substance; at each of the four corners there is a long or short prolongation of the egg shell. In the dog-fishes these prolongations consist of long, twining tough filaments, which like the tendrils of plants, twine round sea-weeds or other submerged bodies, to which they are securely moored. The eggs of some few fishes are oval, not globular, as in the *Myxine glutinosa*, "glutinous hag" of our own shores. The case is horny and at each end there is a thick bundle of short filaments, each thread ending in a triple hook, which probably serves to fix it to some object. The eggs of the gar-fish (*Belone*) are each one loosely enveloped in a thin flocculent mass of the finest gossamer threads, and the eggs are attached in lines one to another by these threads.

*Size of the eggs.*—The eggs of bony fishes vary much in size, independently of the size of the female fish. Some eggs are large, as in the stickleback and the salmon; some are very small, as those of the eel, herring, cod, etc. As a rule, the larger the size the fewer the numbers. The eggs of individuals of the same species do not differ in size; those of a fish four years old will not be larger than those of one which spawns for the first time in its life.

*Impregnation.*—Excepting in the viviparous fishes and the sharks and rays, the eggs of all other kinds are impregnated immediately after exclusion; the male pouring forth his milt either close to the female, or a little distance below her.

It is probable that the spermatozoa of the male can only gain admission into the germ of the ovum through the minute pore known as the micropyle with which the ovum of most animals is provided.* This small aperture is difficult to detect in many cases. I would recommend that any one who wishes to become acquainted with this micropyle, should take trouts' or salmons' eggs for examination. If the egg be wiped dry and held in the left fore finger and thumb and turned round slowly, under view through a lens magnifier, with careful adjustment of the light from the window, a small depression will be seen on the surface of the egg-membrane; in the centre of this depression is the minute pore through the membrane by which the spermatozoa gain entrance. It is extremely difficult to make out at first; but if the observer will divide with a sharp knife an ovum into two equal parts, and clear the segments of their contents, well washing the outside and inside with a soft camel-hair brush; and then dry each segment, putting them both into a cup full of water, they will float like two little transparent coracles; after a while the segment which has the micropyle will sink, the other will continue to float; thus proving the existence of the micropyle.

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* I believe that the micropyle has not been observed in the egg of the frog and toad.

A small piece of the egg-membrane containing the micropyle, if carefully set up as a microscopic object, will show the little pore. Perhaps a single spermatozoid if it enter the 'little gate' is sufficient for impregnation, but I believe I am correct in saying that nearly all efforts to witness the actual ingress of the spermatozoa through the micropyle of a fish's egg made by most excellent naturalists and practised microscopists have failed. Since the days of Dr. Ransom who first described the micropyle, and who observed the passage of the spermatozoa through the foramen into the egg, microscopists have often tried to see the same phenomenon, and always experience great difficulty in the case of fishes. However, there is not the slightest doubt that the phenomenon takes place, and that the spermatozoa enter the egg-membrane through the micropyle, and probably by no other means, for they cannot penetrate the tough enveloping membrane containing the germ, which is characteristic of the eggs of several fishes.

Axel Boeck says "I have frequently found a number of dead spermatozoa sticking fast by their heads to the egg-membrane near the micropyle, but I have never witnessed their actual entry, although I have frequently made attempts to see the phenomenon, but so far without success."

Mr. J. A. Ryder* observes that the effects are soon visible, as the remarkable phenemenon of segmentation, which begins soon after fertilisation has been effected.

When we consider the incalculable number of spermatozoa—each single one of which is able to fecundate an egg, —which the ripe milt of fish must contain, we can readily understand how by its distribution in water countless thousands of ova receive that influence which in time will convert the germinal vesicle into an active swimming fish like the parent; we can see too how, if admission is only to be gained through the micropyle, incalculable numbers of sperm vesicles are necessary to ensure the fertilisation of the eggs, though millions and millions of spermatozoa must die without performing their vitalizing influence. The natural circumstances attending the phenomenon of fish spawning has, as Günther remarks, rendered artificial impregnation more practicable in fishes than in any other class of animals, but as there is great difference amongst fishes as to the mode of deposition of their spawn, and in the time and conditions favourable to development, it is a matter to be learnt by experience in each particular family or genus, or even species of fish, what the required conditions to ensure success may happen to be. The spermatozoa enter only newly-laid eggs; if the eggs remain any time, say half-an-hour in the water, they absorb the water, which creates changes in the eggs, and the spermatozoa cannot impregnate them. The spermatozoa, I have reason to believe, will retain their power much longer than the eggs will theirs.*

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* Development of the Spanish mackerel (*Cybium maculatum*) in Bulletin of the U.S. Fish Commission, 1881, p. 135–165.

*Mode of deposition of eggs.*—Some fishes deposit their eggs in most curious places. *Rhodeus*, as already mentioned, places them within the valves of Molluscs. *Aspredo*, one of the *Siluridae*, after having deposited the eggs upon the ground, presses her belly, at this time of a spongy texture, upon them, and the eggs becoming fixed, she carries them about with her, reminding one of the Surinam toad, which carries her ova on her back. Another fish, the *Solenostoma* of the Indian ocean, carries her eggs in a pouch formed by the coalescence of the long and broad ventral fins (see figures of these fish in Günther's 'Study of Fishes,' pp. 161, 162). These are the only two instances of females taking care of the eggs and young ones at present known. Generally it is the male upon whom this duty devolves, as occurs in the familiar case of the little sticklebacks (*Gasterosteus*) of our own ponds and ditches; the male of this fish as well as of *Cottus*, *Cyclopterus* (Lump fish), *Antennarius* and other genera, construct a nest and jealously watches over the eggs which the female has deposited therein.

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* I have kept the milt of the common trout without water for two days—the spermatozoa still retained their characteristic movements, but not so actively as when quite fresh.

In the pipe fishes (*Syngnathidæ*), there is a kind of pouch in the abdomen near the tail formed by a fold of the skin, the free margins of the fold being firmly united in the median line. The female casts her eggs into this abdominal pouch, and in that curious locality the young are hatched and retained till old enough to leave their father's apron-strings. Dr. Hensel has found that the male of some species of *Arius* (one of the *Siluridæ*), hatches the eggs in his mouth.*

The interest which attaches to the mode of deposition of the eggs of our commercial fishes, the conditions necessary or most favourable for their development, the most suitable localities for the growth of the young fish, and considerations of a kindred nature, although not so curious, are more important by far. For many years it was commonly believed that almost all our sea fishes deposited their spawn at the bottom of the water, but it is now known that a great many of them deposit their eggs on or near to the surface, and that there they float and develop, and there for a time the young fry disport themselves.

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* See also other instances in Agassiz's 'Journey in Brazil,' p. 220.

It is not easy to exaggerate the importance of this discovery, first made by Professor G. Ossian Sars—a worthy son of a most worthy father—about the year 1868, I think. Sars first proved this in the case of the cod-fish, then in that of the gurnards, the flat-fishes (*Pleuronectidæ*), and the mackerel, and both he and Malm added others to the list of surface-egg spawning fishes. Those who have been in the habit of conversing with the fishermen of our coasts know how strongly implanted is their belief that the spawn of fishes always lies at the bottom or near the bottom among weeds.

In a letter with which Professor Sars has kindly favoured me, he says that surface-spawners are considered by him to be the general rule, and ground spawners quite the exception. Ignorance of this fact might possibly have resulted in serious mischief to our trawl-fishing; so great was the cry against the use of the trawl on account (among other wicked deeds it was supposed to do), of grubbing up from the bottom the spawn of fishes, and destroying it; so strong was the clamour for legislative interference in prohibiting the trawl at certain seasons, or restricting its use generally in some way or other, that there was at least a chance of the enactment of prohibitive measures; but thanks to the sagacity, diligence and fairness of Professor Huxley, Mr. Caird, and Mr. G. Shaw-Lefevre, who served on "The Fishing Commission to Report on Questions relating to our Fisheries," appointed in 1863, prohibitive measures of the kind mentioned were strongly denounced. Sars had not at that time discovered that sea fishes spawn at the surface; it was known to fishermen that herrings do spawn on or near the ground; and therefore it was hastily assumed by them that all other fishes did the same; but the Commissioners, though they did not know what had not yet been discovered, came to their conclusions from the evidence before them, and trawling was pronounced to be a legitimate method of capturing fishes; and so no prohibitive act of this kind was fortunately ever passed. I mention this here because it shows how desirable and necessary it is to acquire a knowledge of the various zoological facts, before we put in force by state-machinery prohibitions which may prove to be not only useless in themselves but mischievous to our commercial interests.

More facts with respect to the spawning of our sea fishes still remain to be known, and there is no doubt that the interest aroused by the Great International Fishery Exhibition will prompt many to a study of those points in the life history of our various food fishes and such kindred subjects, which will bear fruit both pleasant and profitable.

There is no doubt that, to ensure impregnation, the ova and milt should be fresh, and as Hensen has observed, if the eggs are to be impregnated, it is necessary that the water be full of freshly emitted spermatozoa, and this is probably the reason why fish, as herrings and cod, are always found in large schools during the spawning season. "All through the school the male fish emit their semen, so that the water looks if not white, at any rate quite muddy. In this water the eggs are laid, and are copiously covered with the spermatozoa. If the fish were to swim near the surface in couples the impregnation would be very imperfect, but the larger the shoal of fish the more evenly will the spermatozoa be distributed in spite of wind and current. Fish which spawn in this manner must therefore first of all gather into schools. It seems that on reaching the coast, they (herrings) move to and fro for some time (weeks or months,) and during this time gather in schools, all of the fish which compose them having about equally developed sexual organs. This is the reason why the herring fisheries yield such a good income. The fish are so closely massed together that large numbers can be caught with little trouble and loss of time. When passing over so called cod-fish banks, such as are favoured by the cod-fish whilst spawning, the plummet will scarcely reach the bottom, because it falls from fish to fish. When the herrings on their way to the spawning places pass through the Schlei, they can easily be speared or caught with a hook, as the water is completely filled with them. If the herrings spawned in pairs, the method of fishing would have to be different from what it is now, and the fishing would scarcely be profitable." ('Scientific Examination of the German Seas,' Report, U.S., p. 552.)

*Floating eggs.*—I have taken floating ova in the North Sea 60 miles from land in a surface net. One would perhaps be inclined to think that so delicate a thing as a fish's egg would be unable to stand the violence of the wind and the motion of the waves ; some fishes' eggs are tough and elastic, and are not injured by rough treatment so far as relates to the egg-membrane. The eggs of some fish can stand great pressure. I forget what weight I have tested trout ova with, but I know that I was astonished at the great pressure they are able to bear without breaking. But the egg-membranes of floating fish eggs are generally very thin. Still, delicate floating organisms can stand a good deal of rough water ; even the small medusæ, as *Beroe* and *Cydippe*, and that fragile-looking glassy cylinder of annelid life, the *Sagitta*, I have taken in abundance in a surface net, when the water was so rough that I was unable to keep my legs without support. Fishes' eggs, however, run a risk of being driven ashore and left on the sand, if they are deposited very near to the coast,* but so enormous is the produce of the Sea's Harvest in this respect that, though millions may be sometimes washed ashore, the yield of fish suffers no appreciable diminution. Perhaps other fishes destroy large numbers of floating eggs; the herring for instance, which one may observe in an aquarium to swim about with mouth partly open, and not continually opening and closing its gill-apertures to any visible extent, apparently quietly imbibing minute floating organisms to be sifted by the gill-rakers and there retained till a collection is ready to be swallowed. The herring in this way, perhaps almost unconsciously, must take in such floating ova as it may happen to meet with in its wanderings. Still if we kept multiplying any natural destructive agencies, the ova are so inconceivably numerous that it is probable no diminution would be apparent in wide areas.

*Ground eggs* are much more likely to suffer from destructive enemies than floating eggs; being deposited often in large masses, their size would render them conspicuous and attract numerous devourers. Herrings' eggs are attached either to the bottom of the water or to some weed or submerged body; but what is more multitudinous than the herring? Eels and crabs have the credit or discredit of devouring quantities of herring spawn, and doubtless these creatures, with probably many others, are not guiltless of the charge. Still the fact of the supply is so vastly in excess of the destruction that, here again, the natural destructive agents probably cause no appreciable diminution.

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* Mr. Oldham Chambers ('Fish and Fisheries,' p. 186) enumerates amongst the adverse circumstances attending the development of cod-eggs "the ravages of a multitude of predaceous fishes, particularly the *Medusæ* family (!)" What does he mean?

It is far different, however, with fresh-water fish, whose ova are deposited in masses, or which are attached distributively even in small grains over aquatic plants. Compared with that of the sea the fresh-water fish-produce is small indeed. A limited area can be swept clean but not the ocean's vast expanse. Any one who has noticed the ruthless way in which a pack of hungry sticklebacks will tear to pieces a comrade's nest and gobble up the contained ova, as eagerly as a pack of hounds will devour a fox, will admire and wonder at the parental fondness of the male fish and his dauntless bravery in defending his nest from all attacking enemies, and will understand how, were it not for his bravery and self-devotion, various foes would in time sweep a limited piece of water almost clear of the breed. For fear of enemies, at any rate as a safe retreat, the common miller's thumb of our streams deposits its pretty pink clusters of eggs under a stone. And even a diminution of such fresh-water fish as deposit their small granular eggs distributively on water weeds, as the carp and tench, would be readily caused in limited areas by a complete eradication from the pond of the weeds which contain the eggs. Fortunately the wide seas' rich "egg field" cannot suffer in this way or in any other.

*Development of the eggs.*—There is considerable difference in the time required for the hatching of the eggs, not only in fishes of different species, but in those of the same species. The latter case chiefly depends on the temperature of the water. As stated under "Herring," Möbius has shown that development is not interrupted by a temperature approaching zero, nor by one rising as high as 15° C. (58° F.). In cold water, however, development is slower than in warm water, and this is doubtless true in other fishes, other conditions being equal. At a temperature of 3° to 5° C. the young Baltic herring escapes from the egg after forty days; at 7° to 8° in fifteen days, at 10° to 11° in eleven days, and with a still higher temperature in six to eight days. I learn from Mr. Dunn, of Mevagissey, Cornwall, that some herring spawn which he sent to the Brighton Aquarium on the 12th of March has now, April 18th, all hatched out. The spawn was taken from the herrings caught in Mevagissey Bay, where it sticks to the bottom. Mr. Dunn says it was beautiful to behold as it stuck to the sides and bottoms of the six bottles which he sent up; the ova are just a shade larger than those of the pilchard. The time which intervenes therefore between the taking of the spawn and the evolution of the embryos occupied about thirty-eight days in the Brighton Aquarium. It will be an interesting matter to watch their growth and progress; unless they are supplied with plenty of minute organisms from their earliest days I fear most must die. If the tanks are well supplied with stone and rock-work well covered with vegetal growth, especially diatomaceæ, the water will be full of minute animal and vegetable life of microscopic size suitable to the stomachs of the young fry. Above all they must not be kept too crowded.*

The experiments made by Mr. J. A. Ryder on the development of the Spanish mackerel (*Cybium maculatum*),† resulted in showing a remarkable difference in time required for the evolution of the young fish. If the temperature of the water was unusually low, 36 hours would be required for the eggs to hatch, but with a warmer temperature 24 hours were found to be sufficient, and some ova hatched out in the short period of 20 hours. Experience alone, probably, would determine what kinds of fish-ova admit of a rapid hastening process of development by an increase of the temperature, and perhaps we have yet to learn whether such fry as are thus quickly developed from the eggs are as strong and healthy fish as those whose development is normal. The French pisciculturists have paid attention to this matter of temperature in the case of some fresh-water fish, and it has been stated that salmon and trout ova, which normally require from 60 to 70 days, or from 50 to 60 days, respectively, are sometimes hatched in 30 days; it is also stated that pike's eggs which normally require about 21 days have been hatched in 9 days, and charr, whose usual time is 21 days, have required in a warm temperature only 12 to 15 days. A knowledge of the influence of temperature on the hastening and retardation of fish-eggs has a very great practical importance: as a very low temperature, by checking development, enables us to transport ova from one climate to another, as those of salmon and trout by means of ice, etc., a rapid development by increased warmth would supply naturalists with materials for study "at a short notice," and pisciculturists with young fry to suit any urgent demand. See an account of experiments on the retardation and acceleration of the ova and the shad in the 'Bulletin of the United States Fish Commission,' vol. i., p. 177, 1881.

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* Mr. Dunn writes to me that he impregnated the spawn when out at sea on an exceedingly cold day; he used both the dry and wet methods with complete success. Since the above was written I learn (April 27) that all the little fry sent to the Brighton Aquarium have perished.

† This is not the fish we know as the Spanish mackerel, which is a *Scomber*. These English names are sadly apt to mislead, unless the scientific names be given.

*Natural Enemies of Sea Fishes.*—The enemies or the destructive natural agents of sea-fishes may be devided into (1) living predaceous creatures, such as mammalia, birds, certain of the reptilia, fish, some of the cephalopoda, certain insects amongst the beetles or coleoptera, either in their perfect or larval state, all of which classes contain animals which feed upon fishes, whether adult or as fry. (2) Parasitic animals, whether external, as *epizoa*, or internal, as various kinds of *entozoa* or intestinal worms. (3) Parasitic vegetable growths, as mould or fungus (*saprolegnia* and *achyla*). With the latter sea-fish are not to any extent troubled, and they may be passed over here. In the first division are to be enumerated, as sea-fish enemies, otters, near the coasts; seals, porpoises, &c; gannets, gulls, guillemots, razor-bills, puffins, cormorants, divers (*Colymbidæ*), &c., among birds; among the reptilia the sea-fishes of our coasts have no enemies. The greatest and most numerons of fish-enemies are to be found among the fish themselves; some of these have been mentioned when considering the different species of fishes, and further notice is deemed unnecessary. Some of the *cephalopoda* prey upon fishes, and probably encircle, as in the tentacular apparatus of the *octopus*, numbers of small ground fishes. No insect, properly speaking, *exists* in the sea, away from the land. Fresh-water fishes in their young state suffer considerably by the depradations of some of the coleoptera, as *hydrous* in its larval form, and *dyticus* both in its larval and imago form; sea-fishes therefore have no insect enemies. Some of the *crustacea* among the more active *macroura* (lobsters) and *brachyura* (crabs) eat fishes when they can catch them, but less active prey is their usual food. Of parasitic animals we have various forms of crustacea, as *aega* ("fish-louse") among the isopoda, *lerneonema* ("eye-sucker" of the sprat and herring), *lernea* ("gill-sucker" of the cod and other *gadidæ*), among the *lerneadæ*, and *caligus* on the bodies of various sea-fishes, and especially in the mouth and branchial cavities. It is certain that fish sometimes suffer considerably from the presence of these epizoa when they occur in great numbers; how far, however, their presence is the cause of the injury to the fish or the consequence of its previous sickly condition, because it is the less able to rid itself of these pests, one cannot actually determine. Probably they are both the cause and consequence of the fish's weakness. In any large quantities certain *caligi* on the bodies and in the branchial cavities would undoubtedly cause serious mischief; and, again, a previously weak or diseased fish would render itself especially liable to suffer from such parasites. That certain parasites, when they are found in any great numbers in the mouth and branchial cavities of some fishes, quickly destroy them, though previously quite healthy, I have experimentally made myself certain. The embryos of the freshwater mussel (*anodon*) are in their early state parasitic upon fishes; in placing some of these creatures in the mouth of a living stickleback, active and hearty, in a few days the fish was dead; I have done the same with *Gyrodactylus elegans* with the same result. The large sturgeon, which for years lived a quiet peaceful life—the "mitis balæna mosellæ" of Ausonius—in the large tank of the Southport Aquarium, died not very long ago from the presence of one kind of these branchial parasites in its gills; I think it was *Lernea branchialis*, but I did not see specimens. Perhaps if this great fish could have been conveyed out of its salt-water tank into freshwater for a temporary sojourn it might have then eased itself of its adversaries, and been still alive to delight the visitors by the mode in which it used to pounce upon its "grub." *

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* The disappearance of certain marine epizoa when the fish enters fresh-water is well-known; and fresh-water parasites as *Argulus foliaceus* and *Piscicola* cannot live in salt-water.

Of parasitic fish mention must be made of the borer, or glutinous hag (see under "Cod-fish"), and the lamprey (*petromyzon*), which rasps away the flesh from its living victim, whilst with its suctorial mouth it keeps firmly fixed on, carried about as an unwelcome guest by the unfortunate host.

A short notice of the *Filaria* (*Agamonema*) *piscium*, one of the most troublesome and common of the entozoa or internal worms, which sometimes bores into the flesh of some of our sea-fishes or causes them to be totally unfit for food, will be found under "Mackerel" and "Herring." The investigation of such matters is attended with extreme difficulty, as little is known of the life history of these fish parasites. I profess to no special knowledge on such matters, and will merely remark that there is a wide and probably not an unprofitable field open here for the student of Helminthology.

*The food of sea-fishes* is of the utmost importance to the fish themselves and to ourselves as consumers of fish; to the fish because the quantity of suitable food tends to their reproduction, growth and general happiness, and to ourselves because on the abundant supply of nourishing fish-food depends an abundance of excellent and wholesome food-fish, and, as a consequence, to some extent, the welfare and prosperity of the nation. Lacépède was not guilty of much exaggeration when he said, speaking of the herring, "Le hareng est une de ces productions dont l'emploi décide de la destinée des empires." Nor is M. Alphonse Esquiros to be accused of hyperbole when he says that herrings placed in barrels "changed the destinies of Holland, and with them those of the world, in the sixteenth and seventeenth centuries." (*Dutch at Home,* i. p. 210.)

Where there is a lack of fish-food there is sure to be a lack of food-fish, as well as of other sea creatures, so that all sea-water is not equally supplied with fish; and a knowledge of the physical geography of a district may to a certain extent show us the reason of a comparative abundance or deficiency of the creatures which may or may not be found in the adjacent waters. Similarly strong currents over certain areas may sweep everything off the bottom.

*Food localities.*—Hard rocky bottoms, destitute of mud, are quite unfavourable to the growth of animal or vegetable life. Alexander Agassiz, the well-known eminent American naturalist, speaking of some dredging excursions carried on in June and July, 1880, U.S. Coast Survey, steamer *Blake*, writes: "We were greatly disappointed in the richness of the fauna on the lines off Charleston and in the Gulf Stream, owing partly to the very gradual slope of the continent towards deep water and the strong current of the Gulf Stream, which sweeps everything off the bottom along its course. There is but little food for the deep-water animals, and it was only along the edges of the Gulf Stream, where mud and silt accumulated, that we made satisfactory hauls on our southern lines. Not until we trawled on the deep slope of the Gulf Stream plateau, south of Cape Hatteras, where the bottom was fine mud and globigerina ooze, was it that we made a rich harvest again, in striking contrast to the poor hauls along the well-swept rocky bed of hard bottom of the Gulf Stream to the southward." (*Bulletin of the Museum of Comparative Zoology;* Harvard College, Cambridge, vol. vi. p. 147.)

Some admirable observations by Professor K. Möbius, on the 'Food of Marine Animals,' will be found in that part of this Essay which treats of the Herring.

The food of fishes varies according to their kinds. Fishes may be exclusively carnivorous or herbivorous, or they may feed on animal and vegetable matter. Again, it is certain that mud or ooze containing animal or vegetable matter, either in a living or dead state, enters largely into the diet of several of our sea-fishes. The presence, size, and form of the teeth, or the entire absence of teeth, gives us an indication of the nature of their food. Fish with large and sharp teeth are carnivorous, preying upon other fish or upon individuals of their own species, or on other free-swimming resisting animals, which they pursue with incessant activity. Fish with strong crushing molars are eminently adapted for breaking hard substances, as crabs, molluscs or stony corallines. Though fishes are by no means dainty in the choice of their food, some kinds nourish them better than others. Some fish will swallow almost anything that comes in their way; this is probably the case with cod. The ling, too, is almost omnivorous. I was told by a smack-owner at Brixham that he had taken a sucking-pig out of a ling's stomach. Probably a sow on board some vessel had farrowed, and a dead young one had been thrown overboard.* The haddock is a very voracious fish, and feeds on various kinds of food, as other fish, crabs, molluscs, small echinodermata and sand stars. I found the stomachs of the haddocks in the North Sea often full of what one would suppose could afford very little nutriment, namely, of *ophiuræ.*

Fish and other sea creatures often swallow apparently very unnutritious food, and, to make up for want of quality, they take in large quantities. The large globe echinus or sea-urchin, obtained by trawling and dredging, feeds in a great measure upon the sand at the bottom of the water; of course such sand must contain some nourishment in the shape of dead or living matter; but the contents of the stomach of a sea-urchin to the eye look like clear sand or arenaceous silex, in itself wholly innutritious. The capacity of the intestinal canal of the sea-urchin is immense; the winding viscera, when full, looks like great spiral sausages of sea-sand.

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* Buckland records the capture of a ling which had in its stomach a metal flask half-full of spirits.

Fish which habitually feed on hard dry food often have the walls of the stomach thick and muscular; as in the case of the haddocks I examined, whose stomachs reminded me of those of the Gillaroo trout, which feed principally on shell-fish. But this is not always the case. A strong muscular stomach is not always correlated with hard and dry food, for the grey mullet, which feeds chiefly on mud, from which it extracts sufficient nourishment to make it one of the fattest of all fishes, has still stronger stomach-walls than either the Gillaroo trout or the haddock; in fact, the stomach of the grey mullet is more muscular than that of any other fish I ever examined.

Those fish which feed largely on solid food are themselves as a rule firm in texture of their flesh, as haddocks and gurnards. Those, on the contrary, whose food is principally of a soft and watery nature are themselves soft and watery, as the plaice. Of all kinds of food which make the best meat of our commercial fishes, I consider that crustacea, such as small crabs, shrimps, entomostraca, &c., stand first. Soles feed on various substances—small crustacea, molluscs, small fishes occasionally; but the favourite food of the sole, and that food which serves to make it into the best meat, consists of marine worms in undance. The large lug-worm (*Arenaria piscatorum*) often found in the stomachs of soles. These latter fish also swallow large quantities of mud—although, perhaps, the mud I have found may be that which the worm has swallowed in most instances. When held up to the light this dark mud is conspicuous in the body of the fish. Soles caught on clean sand are not, generally speaking, nearly so well fed as those which swallowed worms and mud. The lemon-sole (*Solea aurantiaca*, Günth.) is caught principally on the clean sand; its flesh is not equal to the mud-fed soles. But to return to the crustacea as an article of fishes' diet. There seems to be something particularly nutritious in crustacean food when received into the piscine stomach. Mackerel, herrings and pilchards, all fat fish when in best condition, consume immense quantities of small crustacea, whether in the form of the larvæ of the larger kind, or as adult entomostraca. I have found the stomachs of mackerel, in the summer, full of small crustacea, and with little else; young herrings ("whitebait"), one to three inches long, feed chiefly on entomostraca; their little stomachs are often crammed with these minute creatures.* Pilchards, which are entirely destitute of teeth, and therefore incapable of retaining resisting prey, consume large quantities of the same food; but I find that these latter fish feed also most extensively on the smaller kinds of marine algæ, such as diatomaceæ; and these I have also found, to some extent, in the stomachs of herrings. I found the North Sea swarming with crab-larvæ in July. Marine entomostraca would appear also in great abundance on or near the surface about the beginning of May, and continue in many areas all through the summer. Let us consider how this swarming stock of nourishing food is, by the size of the individuals which compose it, fitted for the capacity of the fry of our surface-swimming fishes for months after they have been born; and not for them only, for it has been shown by the investigations of Sars and Malm, as already mentioned, that the fry of several of our sea-fishes, whether surface-swimmers or ground-swimmers, are for a period of their existence inhabitants of the upper strata of the water. Most of our sea-fishes spawn in spring and summer, just at the time when the required food for the little fry is most abundant. Let us own, then, how much we are indebted to these microscopic crustaceans, which thus play so important a part in nourishing the millions of young herrings, themselves destined in time to help to nourish, at a cheap cost, hundreds of thousands of the working-classes of our land. Of course there are many other small organisms, whether animal or vegetable, which afford food to the herrings, and to the fry of numerous other fishes. But the small crustacea are certainly among the most important articles of fishes' diet.*

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* It has been supposed that salmon owe the redness of the flesh to crustacea, the gastric juice of the fish turning the flesh red, as boiling does lobsters.

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* The existence of abundant microscopic organisms to feed the minute young fry of our sea-fishes is obviously necessary, and it is quite probable that the occasional absence of such food for a sufficient time in fishes which have spawned at abnormal seasons, or when ova or fry may have been carried out of the reach of food, may have resulted in the production of those curious elongate, pellucid, muscular, band-shaped creatures called *Leptocephali*, which have a segmented *chorda dorsalis* instead of a true vertebral column, and which never develop generative organs. From the absence of suitable food, or at any rate from the absence of those conditions necessary for the development of the embryos, be they what they may, these *Leptocephali* have been arrested at their growth in infancy, but for a time exist as undeveloped "hydropic forms of fish-life, which die before they attain e characters of a perfect animal" (see Günther's 'Study of Fishes,' 81; also under "Conger.")

## SEA FISHES IN RELATION TO MAN.

The most obvious and important relation in which sea-fishes stand to man is evidently that of supplying him with food; but fish-flesh affording also certain special substances, is useful as a medicine; and, thirdly, there is the utilisation, as offal, of parts not available for food, for manure or other purposes.

As to food it is clear that we should know that it must have nutritious qualities to be of any real service; we should determine in what proportion it has nutritive qualities compared with other kinds of animal food. I do not know whether any recent experimental tests have been made on this subject. Some years ago Dr. John Davy, the brother and biographer of Sir John Davy, an eminent chemist and physiologist, conducted certain experiments with a view to ascertain the value of fish in relation to diet, and in his *Physiological Researches* (London, 1863) he has a valuable chapter on the Nutritive Power of Fish; and on the Peculiar Qualities of Fish as Articles of Diet. The first part of his remarks I will quote word for word.

"*Of the Nutritive Power of Fish*:—The proposition probably will be admitted that the nutritive power of all the ordinary articles of animal food, at least of those composed principally of muscular fibre, or of muscle and fat, to whatever class belonging, is approximately denoted by their several specific qualities, and by the amount of solid matter which each contains, as determined by thorough drying, or the expulsion of the aqueous part, at a temperature such as that of boiling water, not sufficiently high to effect any well-marked chemical change. In the trials I have made, founded on this proposition, the specific gravity has been ascertained in the ordinary hydrostatical way; the portions submitted to trial, in the instance of fish, have been taken from the thicker part of the back, freed from skin and bone, composed chiefly of muscle. And the same or similar portions have been used for the purpose of determining their solid contents, dried in platina or glass capsules of known weight, and exposed to the process of drying till they cease to diminish in weight.

"The trials on the other articles of diet, made for the sake of comparison, both as regards specific gravity (excepting the liquids) and the abstraction of the hygroscopic water, or water capable of being dissipated by the degree of temperature mentioned, have been conducted in a similar manner. The balance used was one of great delicacy when at home, or a small portable one when from home, of less delicacy, yet turning readily with one tenth of a grain.

"The results obtained are given in the following tables: in the first, on some different species of fish; in the second on some other articles of animal food. I have thought it right, whenever it was in my power, to notice not only the time when the fish was taken, but also the place where they were procured—not always so precise as I could wish, as both season and locality may have an influence on their quality individually. Where the place mentioned is inland, it must be understood that, in the instance of sea-fish, they were from the nearest seaport.

"These results I would wish to have considered merely as I have proposed in introducing them, viz: as approximate ones. Some of them may not be perfectly correct, owing to circumstances of a vitiating kind, especially the time of keeping. Thus, in the case of the whiting, which was brought from Chester, its specific gravity and its proportion of solid matter may be given a little too high, owing to

TABLE I.

| Species of Fish. | Spec. grav. | Solid matter per cent. | Place where got, and time. |
|---|---|---|---|
| Turbot, *Rhombus maximus* . . . . . . | 1,062 | 20·3 | March. Liverpool. |
| Brill, *R. vulgaris* . . | 1,061 | 20·2 | Oct. Penzance. |
| Haddock, *Gadus æglefinus* . . . . . | 1,056 | 20·2 | Aug. Ambleside. |
| Hake, *G. merluccius* . | 1,054 | 17·4 | Oct. Penzance. |
| Pollack, *G. pollachius* | 1,060 | 19·3 | Oct. Penzance. |
| Whiting, *merlangius vulgaris* . . . . | 1,062 | 21·5 | March. Chester. |
| Common Cod, *Morrhua vulgaris* . . . . | 1,059 | 19·2 | April. Ambleside. |
| Red Gurnard, *Trigla cuculus* . . . . | 1,069 | 23·6 | Oct. Penzance. |
| Dory, *Zeus faber* . . | 1,070 | 22·9 | Oct. Penzance. |
| Mackerel, *Scomber Scombrus* . . . . . | 1,043 | 37·9 | Oct. Penzance. |
| Sole, *Solea vulgaris* . | 1,065 | 23·0 | Feb. Ambleside. |
| Ditto, *ditto* . . . . | 1,064 | 21·1 | Feb. Ambleside. |
| Thornback, *Raia clavata* . . . . . | 1,061 | 22·2 | Oct. Penzance. |
| Salmon, *Salmo salar* . | 1,071 | 29·4 | March. River Boyne, Ireland, fresh run from the sea. |
| Sea Trout, *S. eriox* . | .. | 41·2 | June. Ambleside. |
| Char, *S. umbla* . . . | 1,056 | 22·2 | Nov. Windermere. |
| Trout, *S. fario* . . . | 1,053 | 22·5 | March. Lough Corrib, Ireland, weight about ¾lb., good condition. |
| Ditto, *ditto* . . . . | 1,050 | 18·7 | Oct. River Brathray. Small fish, about 2 oz. |
| Smelt, *S. eperlanus* . | 1,060 | 19·3 | March. Liverpool. |
| Eel, *Anguilla latirostris* | 1,034 | 33·6 | June. Ambleside. |

TABLE II.

| Kinds of Food. | Spec. grav. | Solid matter per cent. | Time and place. |
|---|---|---|---|
| Beef, sirloin . . . . | 1,078 | 26·9 | March. Ambleside, |
| Veal, loin . . . . | 1,076 | 27·2 | Nov. Ambleside. |
| Mutton, leg . . . . | 1,069 | 26·5 | Nov. Ambleside. |
| Pork, loin . . . . | 1,080 | 30·5 | Jan. Ambleside. |
| Pemmican, composed of beef and suet . . . . | .. | 86·25 | Victualling Yard, Portsmouth. |
| Common Fowl, breast | 1,075 | 27·2 | Nov. Ambleside. |
| Grey Plover, breast . | 1,072 | 30·1 | Nov. Ambleside. |
| Cow's Milk, new, before cream had separated | 1,031 | 11·2 | Nov. |
| White of hen's egg . . | 1,044 | 13·9 | |
| Yolk of the same . . | 1,032 | 45·1 | |

some loss of moisture before the trials on it were made. Casting the eye over the first table, it will be seen that the range of nutritive power, as denoted by the specific gravity and the proportion of solid matter, is pretty equable, except in a few instances, and chiefly those of the salmon and mackerel, the one exhibiting a high specific gravity, with a large proportion of solid matter; the other a low specific gravity, with a still larger proportion of matter—viz: muscle and oil—and, in consequence of the latter, the inferior specific gravity. A portion of the mackerel, I may remark, merely by drying and pressure between folds of blotting paper, lost 12·52 per cent. of oil. Oil also abounds in the sea-trout and eel, and hence the large amount of residue they afforded. Comparing *seriatim* the first table with the second, the degree of difference of nutritive power of those articles standing highest in each, appears to be inconsiderable, and not great in the majority of the others, exclusive of the liquids—hardly in accordance with popular and long received notions."

Certainly, as Dr. Davy remarks, the results of his trials are not in accordance with popular opinion; and it must be gratifying to fish-consumers to find that there is so large a percentage of nutritive power, nitrogenous and oleaginous, in the fish they consume. Let us cheapen fish by multiplying the mechanical means for their capture, and so increase the supply.

As to the *peculiar qualities* of fish as an article of diet, as to whether fish contains any elements which may be more conducive to the maintenance of the general health, or be more effectual in restoring vital power to diseased or impaired constitutions than the flesh of such animals among the mammals and birds as are commonly used for food, it seems that an answer may be given in the affirmative.

Dr. Davy's researches in connection with this important subject are full of interest and importance. The beneficial use of cod-liver oil as medicinal food of course immediately occurs to the mind. No one doubts its efficacy in mitigating pulmonary consumption. To what particular element in cod-liver oil is its healing or restorative property due? The answer probably is, "to the presence of iodine." Dr. Davy's words are: "As this (cod-liver) oil contains iodine, the analogy seems to strengthen the inference that sea-fish generally may be alike beneficial." The question then arises, Do consumers of large quantities of sea-fish enjoy as a rule, *cæteris paribus*, better health than those who seldom or never partake of it? Or, to come to a more special and definite question, Are such consumers less subject to diseases of a scrofulous and tubercular nature than non-consumers? Dr. Davy is inclined, from the information he has been able to collect, to think that they are "less subject to the diseases referred to than any other class, without exception." Dr. Davy writes: "At Plymouth, at the public dispensary, a good opportunity is afforded of arriving at some positive conclusion, some exact knowledge of the comparative prevalency of those diseases in the several classes of the community. The able physician of that institution, Dr. Cookworthy, at my request, has had the goodness to consult its records, and from a communication with which he has favoured me it appears that of '654 cases of confirmed phthisis and of hæmoptysis, the probable result of tuberculosis' entered in the register of the dispensary, 234 males, 376 females, whose ages and occupations are given individually, the small number of four only were of fishermen's families—one male and three females—which is the ratio of 1 to 163·2; and of water-men, 'who fish with hook and line when other work is scarce, generally very poor, and of habits generally by no means temperate or regular,' the number, including their families, did not exceed eleven, of whom ten were males and one a female, which is in the ratio of 1 to 58·8. The entries from which the 654 cases are extracted, Dr. Cookworthy states, exceed 20,000. He assures me that had he taken scrofula in all its forms the result would, he believes, have been more conclusive."

It may, perhaps, be said that fishermen spend most of their existence on the sea or near it, and are constantly breathing the invigorating salt-water air and inhaling iodine, and that to this they owe their immunity from scrofulous complaints. The answer to such an explanation is that all classes of seaside dwellers are not so exempt, but only fishermen and those who eat large quantities of fish, and that smelling a thing is a very different thing from eating it. It may be doubted whether iodine is taken into the system in any, even infinitesimal, doses simply by respiration; we are constantly breathing nitrogen, but we do not thus get it into the system to feed and renew our tissues; we gain it only by food. Iodine is largely used in medicine with great success, but as it is, except in very small quantities, a dangerous poison, it is preferable to take it as it exists in our fish-food, by all those who habitually are able to do so, than to take it according to the prescription of the pharmacopœia.

Dr. Davy made trials on the following fishes: red gurnard, mackerel, haddock, cod, whiting, sole, ling, herring, pilchard, salmon, sea-trout, smelt and trout; in the saline matter obtained by evaporation from the charcoal washings of the fish, he found clear proof of the presence of iodine by the test of starch and *aqua regia*. The native sources of iodine are sea-water and various marine plants and animals; the iodine of commerce is principally obtained from *kelp* or seaweed; many of our fishes are large consumers of seaweeds, predaceous fishes prey upon these iodine sources, and in this way we can account for the presence of iodine in their flesh. Dr. Davy tells us that he has detected this element in the common shrimp in an unmistakable manner, also in the crab and lobster, and in the common cockle, mussel, and oyster.

The different parts of the same fish, however, are not equally beneficial in the manner referred to; as their inorganic elements are not the same, the effects of different parts are not the same. Davy instances the liver, muscle and the roe or milt; in the latter he detected no trace of iodine or of free alkali, but he detected in those organs another beneficial agent, viz., phosphoric acid, and thus to a certain extent fish-roe and milt may be beneficial in supplying to the brain of man certain quantities of a substance which that organ normally contains to the amount of 2 or 2½ per cent. In the liver and muscle of sea-fish Dr. Davy always found a minute portion of iodine, rather more in the liver than in the muscle, hence a preparation of the liver of the cod-fish, in the case of the well-known oil, is the source whence the supply is derived. As a probable inference of the utility of fish-food in that formidable malady goître (bronchocele), sometimes in our country called "Derbyshire throat," it seems that this disease is "unknown amongst the inhabitants of seaports and sea-coasts, who, from their situation, cannot fail to make more or less use of fish." *

The quality of the flesh of fish as a general article of diet is not always the same at one time of the year as at another; as a rule the flesh is more or less soft just after spawning, insipid, and in some instances—especially the "shotten" herring—it is absolutely hardly worth cooking; after it has recovered from spawning and at all other times, it is rich, fleshy, well-flavoured and nutritious. The ova and milt—"hard and soft roe"—of sea-fishes is generally excellent and wholesome; and I do not know that the roe of any of our British sea-fishes is unwholesome, and almost poisonous, as is the case in some of our freshwater fishes, as the pike and barbel.

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* In fishes which are permanent residents in fresh water there is no iodine.

The quality of the flesh of the different species taken from the same waters depends in a great measure upon the nature of the food which the fish are in the habit of consuming; when a gurnard fills its stomach and intestine with such dry matter as sand-stars, *Ophiuræ* and *Ophiocomæ*, it is no wonder that its own flesh is dry in the palate of the human consumer. When a plaice fills its stomach with little else than soft molluscs, and when the whole intestinal tract is of a watery and pulpy nature, it is likely that its flesh should be also soft. Those fish which feed largely on crustacea are the best food-fish, as I have already observed; and perhaps, with fish as with ourselves, a mixed diet of crustacea, fish-worms and molluscs tends to form the most desirable kind of food-fish.

With respect to the offal—such parts as are of no use to the consumer as food—I will do no more than refer the reader to the admirable essay on this subject by Mr. W. Anderson Smith, 'The Utilisation of Fish Offal' in the recently published volume of the Prize Essays, Edinburgh, 'Fish and Fisheries,' p. 200 to 206.

## SOME QUESTIONS RELATING TO THE WHOLE SUBJECT.

There are many points of interest which might fairly claim to be noticed, but I will select the following for consideration :—

1. Can sea fishes be artificially propagated and cultivated in sea-water ponds or reservoirs?

2. Can any sea fishes be introduced into fresh-water reservoirs with a prospect of success?

3. Can the present modes of capturing sea fishes be increased without fear of diminishing the natural supplies of the sea?

4. Why are fish, especially soles, so dear?

With respect to the artificial propagation of sea fishes much remains to be discovered; for although much attention for many years past has been, and still is being, given to the cultivation of various fresh-water fishes and to the acclimatisation of foreign fish in home-waters, comparatively little thought has been bestowed on the artificial propagation and cultivation of our sea fishes, and experiments are required before it would be possible to say how far such a thing would be likely to be attended with success. There would probably be no difficulty in the artificial impregnation of several of our sea fishes, in the rearing of the fry, in providing the different kinds with suitable food, and placing them in conditions under which they would thrive and grow ; no difficulty that may not be in time surmounted so far as relates to the natural history side of the question ; but what would be the probable cost of forming artificially-constructed reservoirs of salt-water on suitable parts of our coasts in connection with tidal influence, and whether such an undertaking, on any scale likely to be of any commercial importance, would pay, are matters which are open to question. Doubtless the being able to retain for a time in a healthy state a stock of various fishes in confined reservoirs, so as to have them ready at hand for capture, and for sale, would be a great advantage.

Thousands of cod are annually kept alive in the large floating boxes in the docks at Grimsby, and their temporary preservation there is attended with little or no expense, and there is no reason why this plan of having a reserve force should not be adopted generally, where suitable dock accommodation is available. But this is a very different matter from what is meant by the *cultivation* of sea fishes in artificially-constructed ponds.

*Pisciculture by the Romans.*—The ancient Romans, as is well-known, largely practised this marine pisciculture, and at one period of their history it is evident that one object they had in view was a commercial one. Varro and Columella have left us an account of these *vivaria* or *piscinæ*, and as the subject has not only an historical but a practical interest, I will here give in full Columella's two chapters which treat of this subject. As his remarks have never, so far as I am aware, been translated before, and as they show us an ancient successful method, I do so without apology for their introduction here.

Columella, having treated of various matters relating to the agricultural and rural life in connection with kindred topics, proceeds to give some instructions about the cultivation of fishes ("cura piscium"). He says:*

"Since I have spoken of aquatic animals," (he had just treated of water-fowl preserves) "it is not inopportune to speak now of the cultivation of fishes, and although one would think that a digression on this subject is quite foreign to agriculturists—for what are more opposite than land and water?—still I shall not pass the matter over, for our ancestors have made even the study of these things celebrated, to such an extent indeed as to have confined sea fishes in fresh waters, and to have bestowed the same care in the nurture of the grey mullet (*mugil*), and the *scarus* which they now do on the muræna and basse (*lupus*); for that rural offspring of Romulus and Remus considered it a great matter that country life, if it were to be put into comparison with town life, should in no respect be deficient in resources; wherefore they stocked not only the ponds which they themselves had made, but they even filled natural lakes with produce brought from the sea.* In them Velinus, in them also Sabatinus, also Vulsinensis and Ciminius reared basse and sea-bream (*auratæ*), and other kinds of sea-fish tolerant of fresh-water. Later on, a succeeding age abolished that kind of fish-culture, and the luxury of the rich made enclosures round the seas themselves and Neptune, so that even then in the memory of our grandfathers a certain deed and saying of Marcius Philippus,† a man of very luxurious habits, used to be talked about as if they were exceedingly witty; for this man, when by chance he was supping as a guest at the house of

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* Columella, viii. cap. 16.

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* Columella's words are: "Lacus convectis marinis seminibus replebant." Dr. Badham interprets this as meaning the actual eggs of the fishes; I feel sure, however, that the word *semen* simply denotes "produce," "stock," "store." There is no reference in classical authors that would lead us to infer that they practised artificial impregnation, and they were not likely to have been acquainted with the floating ova of fishes.

† Tribune of the Plebs, B.C. 104, the celebrated orator and pleader mentioned by Horace:

> "Strenuus et fortis, casisque Philippus agendis
> Clarus."—Epist. i. 7. 46.

Celebrated also for the extent and magnificence of his fish-ponds.

Catinus, and when he had tasted basse from a neighbouring stream, spit the piece out of his mouth, and followed up his impudent deed by the remark, 'May I die but I thought I was eating fish!' This false oath, therefore, caused the taste of many to become fastidious, and taught the educated palate to disdain a river basse unless it had been one that had struggled in the strong current of the Tiber. Therefore Terentius Varro said, 'There is not a single low fellow nor buffoon who does not now say that it matters not whether vivaria are stocked with fish of that kind, or with frogs. But still in those days, the luxuriousness of which Varro has mentioned, the severity of Cato used to be especially extolled, and yet he, the tutor of Lucullus, sold his ward's fish-ponds for the large sum of four hundred thousand sesterces (equal to about £3,540). For at that time cook-shop dainties were in high request when vivaria, to which men were excessively devoted, were brought down to the sea, just as before that time, Numantinus and Isauricus of conquered nations, also Sergius Orata [Aurata] and Licinius Muræna rejoiced in calling themselves after the names of their captive fishes. But since in this way manners became hardened, we, that we may not appear to be fierce reprovers of so many past ages, but in order that these matters should be regarded, not as common things, but as especially praiseworthy and honourable, will show that this country-house occupation is even a gain to families. For he who has bought either islands or land near the sea, and is unable, from the poverty of the soil generally to be found near the sea, to derive therefrom the fruits of the earth, may make his profit from the sea.

"Now the very first thing to consider is the nature of the where you may have resolved to make your fish-ponds; for all kinds of fish cannot be had from all shores. A muddy region suits the flat fish, as the sole, the turbot and the brill; and the same kind is suited for various kinds of shell-fish.* Sandy streams feed flat fishes fairly well (*non pessime*), but they are better for sea fishes, as gilt-heads and dentrice . . .; † they are not at all good for shell-fish. Again a rocky sea nourishes those kinds which live among rocks, and which in consequence are called rock-fish (*saxatiles*), as the *merulæ* and the *turdi* [perhaps wrasse] and the *melanuri*. We ought also to take into account the difference of the seas, as well as of the shores in order that fish brought from foreign shores may not disappoint us; for every kind of fish cannot exist in every sea, as the *helops* for instance, which is nourished in the Pamphylian Sea, and in no other; as the dory (*faber*), accounted as one of the best fishes in our municipality of Gades, and which according to old custom is called zeus [*zaeus* = ζαιὸς]; as the *scarus*, which is most abundant on all the shores of Asia Minor and Greece as far as Sicily, but never swims out to the Ligurian Sea, nor through the seas of Gaul to those of Spain. Therefore if such fish are brought to our vivaria, let them not be kept long. The muræna alone of the high-priced fish (*pretiosis piscibus*), although indigenous in the Tartessian as well as in the Carpathian Sea, which is its most distant habitat, can live as a guest in any sea. But let us now discuss about the site of fish-ponds.

(Cap. 17.) "We judge a pond (*stagnum*), to be far the best when it is so situated, that each following wave of the sea removes the one before it, and does not permit the old one to remain within the enclosure; for this is similar to what happens in the sea, which, being constantly agitated by the wind, is unable to become warm, because the cold sea rolls the cold wave up from the depth to the upper portion. A pond is either cut out of a rock—though there is seldom necessity for this—or is built on the shore by means of masonry. But in whatever way it is made, it ought to have a hollow cavity near the bottom, if it is to be always kept cold by the influx of rushing water; it should also have other cavities, either simple and straight whither the scaly shoal may retire, or curved in the form of a snail-shell, of sufficient dimensions to allow the murenæ a shelter. Some persons, however, do not like to mix these fish with others of a different kind, because when they are harassed with rabies similar to that which occurs in dogs, they persecute the fishy shoals most savagely and kill many by biting them. Escape-passages, moreover, should be made on every side of the *piscina*, if the nature of the place permit it, for the old water, in whatever direction it is impelled by the wave, is more easily changed if there is an exit for the water opposite to its entrance into the pond. These escape-channels (*meatus*) we think should be made near the bottom of the enclosure, if the situation of the place allow it, so that a plummet let down to the bottom of the pond should show a depth of seven feet of water above; this measure of water is sufficient for the fishes; and there is no doubt that the more the water comes from the bottom of the sea so much the colder it is, and cold is a condition most suitable for the swimming fishes.

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* Columella enumerates several, but I have not time to go into the difficult question of identity.

† The text is probably corrupt here.

"But if the spot selected for a vivarium is on a level with the sea-water, then the pond is to be dug out to a depth of nine feet; streams of water are to be brought in by means of channels within two feet from the top, and care must be [illegible] that these streams come in copiously, because the quantity of water in the pond which is below the sea-level is driven out just as if a fresh rush of sea-water had gained admittance. Many people are of opinion that, in ponds of the nature just mentioned, long and tortuous recesses should be made for the fishes in the sides of the cavity, as dark places of retreat for them. But if fresh sea-water is not continually running through the pond, to do this is injurious, because reservoirs of this kind do not readily admit fresh supplies of sea-water, and with difficulty get rid of the old, and stinking water is more injurious than darkness is beneficial. Nevertheless little holes should be hollowed out of the walls to protect the fish from the heat of the sun; but we ought to remember that for the channels through which the pond receives its water, brass gratings (*œnei cancelli*) with narrow openings should be fixed by which the escape of the fish may be prevented. If space permit, it will be advisable to place in the pond rocks taken from the shore clothed with seaweed, and thus. so far as the ingenuity of man can contrive, to represent the actual appearance of the sea, in order that the confined fishes may be as little as possible aware of their imprisonment. By these means we shall lead the aquatic flock to their assigned stalls. It is well also for us to remember, even in matters relating to water, the one precept related to land questions—'Whatever each region may produce;' for we never should be able, however much we desired it, to feed in a vivarium a multitude of red mullets, as we sometimes see in the sea, because this kind is very delicate and intolerant of captivity; rarely indeed—perhaps only one or two out of many thousands—do they endure confinement, but on the other hand, we frequently witness within the barriers marine shoals of the sluggish grey mullet and the rapacious basse. Therefore, as I have proposed, let us consider the nature of the shore, and if we see it to be rocky let us approve and make our stew rocky. Many kinds of *turdus merulæ* and greedy *mustelæ* and basse, whether spotted or not, we may introduce into the pond, also the floating murena, which are especially esteemed, and other rock-fishes of value, for the cheap sort it does not pay to capture, let alone to feed.

"Those kind of fish which belong to a sandy shore may be kept in the stews; but shores which are full of slime and mud are, as I said before, better adapted for shell-fish and creatures which lie on the bottom. Again a site of a stew which suits flat-fishes, may not suit other kinds; the same kind of food may not do for flat-fishes and those which swim erect; for soles, turbots, and such like fish a shallow depression of two feet in depth is made in that part of the shore which is never left by the retreating tide. Closely set stakes are fixed in the margin of the pond, and these are always higher than the sea-water, even when the waves swell. By and by embankments or breakwaters (moles) are thrown up all round so as to form an enclosure above the height of the tide, for by this means the fury of the sea is broken by the base of the embankment, the fish being in calm water are not disturbed from their places, and the vivarium is not filled by a heap of sea-weed cast up in storms by the fury of the sea. In some places it will also be necessary to interpose earthwork of a meandering form, with small and narrow passages to admit the sea-water without the waves at the most tempestuous times of the winter.

"Flat fishes require softer food than those which are found near rocks, because they are either without teeth and suck up the food, or swallow it entire, but cannot chew it. Therefore you should offer them dripping halec, bits of salt pilchard (? *chalcis*), putrid *sardine*, the gills of *scarus* or any part of the intestines of the *pelamys* and *lacertus*, the bellies of mackerel, dog-fish and *elacate*, and, not to mention further particulars, any kind of salted refuse swept from the fishmongers' shops. I have mentioned many kinds of food, not because all may be had from all shores, but in order that out of these I may offer some which you may obtain. It is proper also to give them green opened figs, and the mild fruit of the arbutus after it has been broken by the fingers, and the crushed fruit of the service tree [*Pyrus domestica*]; also, such as is readily sucked in—as curd fresh from the dairy pail, that is to say, if the locality of the place and the time of the year suit. You cannot, however, give them any better food than the salt fish before mentioned, because it has strong odour, and every kind of flat fish finds out its food rather by the nostrils than by the eyes, because though it always rests supine, it has an upward aspect, and so does not easily perceive what is flat on the ground, either on the right side or on the left. Therefore when salt food is thrown to them they come to it, being guided by the smell. Other fish, however, whether rock-fish or open-sea fish (*pelagii*), are better fed with fresh fish, though they will do with salt, for both the *halecula* newly captured and the *cantharus*, as well as the little goby, and, in fine, every kind of little fish, are food for big ones. But if the severity of winter does not permit this kind of food to be given, then stale bread-crumbs or any chopped-up fruit in season will do.

"Dried figs, especially the large kinds, as the Baetic and Numidian, are always given to them. But that must not be done which many people do, namely, give the fish nothing at all, because, although they are able to sustain themselves without food for a long time, unless the fish is fattened with food supplied by its master, when it is brought to the fish-market its leanness proclaims that it was not caught in the sea but taken from confinement, on which account it loses much of its value." (De Re Rustica, vol. ii. viii. cap. 16 & 17; ed. Schneider.)

It is quite certain that there is a good deal of practical common sense in the above information, and that even modern pisciculturists may derive some useful hints from Columella's instructions. It will be noticed that he says nothing of fish breeding in these vivaria, and I do not remember any classical allusion which would lead us to infer that the ancients had ever this prospect in view. Their objects were to have fish ready for the family consumption, for sale, and, amongst the luxurious and wealthy, simply for the sake of amusement. Of course we lose much in Columella's narration, because it is not at all possible in some cases to identify the kinds of fish of which he speaks; the names of those fishes I have left untranslated. Although we know that these artificial salt-water ponds were very expensive when made and stocked for the amusement of the rich, it would seem, from Columella's advice only to cultivate the fish which would sell well, that it must have been a profitable business, "even a gain to families." Some of the things upon which the Romans fed their fish may strike us as strange; some experiments on this kind of food might be tried.

## ARTIFICIAL PROPAGATION OF SEA FISHES.

There are certain positive conditions which all fish ova require for impregnation and development; other conditions there are which are necessary for some eggs but not for others; and it is scarcely likely, considering the difference existing in the habits and physiology of fishes, that ONE general rule should hold good in all cases. The positive requirements for the impregnation of all fish ova are, that the ova should be mature; that the milt of the male should be ripe; that the spermatozoids of the milt should enter either by the micropyle, or, possibly, in the case of very thin egg-membranes, through the integument; that the mixture of the ripe milt with the ripe ova should take place as soon as possible after the male and female fish have been stripped; that the ova must not be left in the water more than a few minutes before the milt is applied, because a rapid absorption of the water takes place and renders each ovum incapable of afterwards receiving the spermatozoa. It is probable that the fecundating influence of the milt is able under certain conditions, such as being kept in a cool temperature and being unmixed with water, to be maintained for a much longer period than could be allowed for the eggs; but it is always most desirable to use the milt fresh as it flows from the male fish; at this time the spermatozoa are in the highest state of activity, and although I have found the movements to continue for many hours, it is clear that they diminish in activity, and have therefore less power to work their way and penetrate the egg.

It may be taken for granted, as a general rule, that ripe ova and ripe milt flow readily on a very slight pressure of the abdomen; and that only such are thoroughly to be depended upon. Every one who has had any experience in spawning trout, is well aware that in stripping a female the first pressure brings a number of eggs spurting out, and that when the fish has been nearly emptied, the last that appear, if they have required more pressure, are more or less bloody in appearance, evidently not yet quite mature. Fish differ as to the time required before parting with all the eggs from the ovary; some take a short time, others a long one, according as the eggs arrive at maturity. Much has been said the last few years on the system of impregnating eggs known as "dry spawning," in which case the eggs and milt are mixed without the addition of water; some advocate this method, others are rather in favour of the wet. The old system of mixing the ova and milt in a little water, allowing both to remain in a flat wide vessel for about five or ten minutes, then pouring off the water for another succession of ripe and ready ova, and placing the eggs into their appointed places, is as successful as any system can be. I have seen thousands of trout ova thus hatched, and never anticipate a failure in the impregnating process. The presence of the spermatozoa in water with fresh unimpregnated ova causes them at once to absorb water, and the fertilising bodies enter with it into the eggs.

The floating eggs of several fishes have been successfully impregnated by artificial means; all that is required is to attend to the conditions mentioned above, and the artificial impregnation of floating eggs is as simple a matter as that of ground eggs. It is easy to see whether fish ova have been impregnated or not; if they have not, they soon turn white ("blind") and go bad. The ova of cod were, I believe, the first kind operated upon; experiments were commenced at Gloucester, Mass., U.S.A., in August, 1878, by Mr. Milner, who unfortunately died during the investigation, which was completed by Captain Chester, who has detailed the whole process. Mr. Oldham Chambers has also successfully experimented upon cod ova at Lowestoft, in 1882; he tried both the dry and moist systems, and his experiments were successful; the artificial impregnation of floating ova, therefore, has been successfully accomplished both in America and in our own country. But the Americans have not confined their experiments to the cod; the black and striped bass, the

Spanish mackerel, and the shad, among other fishes, have also been operated upon, and all with more or less success.

The treatment of the ova after impregnation is a separate question, and one which requires considerable care and attention, at any rate in the case of some fishes whose ova float. Writing of the Spanish mackerel (*Cybium maculatum*), Mr. J. A. Ryder, a learned American physiologist who has paid much attention to the embryology of fishes, and whose writings are of the greatest value both scientific and practical, mentions the buoyancy of the eggs of the above-named fish as apparently caused by the presence of a large oil sphere in the vitellus. This had been previously observed in our mackerel (*Scomber*) by Sars and Malm, and it has since been noticed by other observers. The cod-fish seems to owe the buoyancy of its ova to the diminished specific gravity of the whole egg. Mr. Ryder insists upon this buoyant character "as being of such great physiological import that we cannot afford to ignore it or to conduct our hatching work without taking cognizance of it in the construction of apparatus. The perfectly regular development of the ova was found to take place practically at the surface of the water, while those which sank to the bottom were considered, in the light of experience, as not liable to develop at all. When the eggs were kept for the whole period of incubation in still water in a marbleised pan, all that sank could be regarded as irrecoverably lost while those which remained floating at the surface as uniformly hatched out. The active movement of the ova in apparatus devised to hatch other species with heavy ova was amongst the least successful modes, and especially where metals, such as copper, brass, tin, or nickel, were used in the construction of the hatching vessels or screens . . . . It may be stated as a general principle that buoyant ova must have gentle treatment; that if they are much agitated in the water they tend to be injured, and are carried to the bottom, where they die. It appeared that when the normal buoyant tendencies of the ova were interfered with by any of our methods, large losses were the result, and that the nearer our methods approached the natural environment of naturally spawned ova in the open sea the more successful we were. To forcibly immerse the egg of the mackerel, and keep it immersed, would simply be to thwart what is most palpably a normal condition of its life at the surface of the water." ('Bulletin U.S. Fish Commission,' vol. i. 1881, p. 162.) Some questions, however, arise here with respect to the agitation of the water tending to injure the ova and to carry them to the bottom, because it may be asked why the agitation of the waves in the open sea has not also the same effect, and cause floating ova to sink? Mr. W. Oldham Chambers, desiring to conform to the natural conditions of the egg in the sea, devised an apparatus that retained a constant tide-like flow in the water "caused by a peculiar turn given to it on its entrance, which held the eggs in perpetual motion;" he states that the results realised every anticipation and left nothing to be desired. It is true that the buoyancy of the cod's eggs is not due to the presence of a large oil globule in the vitellus; but the mackerel's (*Scomber*) eggs are thus rendered buoyant, and they float in the sea in spite of the agitation of the sea-water. If it is a normal condition of its life for an egg to float in the water of the sea, which is always more or less in a state of agitation, then the mere agitation of the water in a confined vessel cannot *per se* alone be an abnormal condition of its life there. However, Mr. Ryder says, "if they are too much agitated;" and the question may be one of degree. Besides, it may be true that violent agitation of the sea-water does injure the floating ova of our various sea fishes, and a warm calm time during the period when floating ova are incubating, may be, for what we know, necessary for a large harvest of hatched fry. All who have paid attention to the cultivation of the oyster are fully aware of the extreme importance to the development of the spat which attaches to quietude and warmth; and it would be interesting to discover, in the case of floating ova, how far the state of an agitated environment affects them injuriously. As I have observed before, I have been struck with the profusion of apparently delicate organisms when trawling in the North Sea in water unpleasantly rough and "choppy."

## FEEDING OF YOUNG FRY.

The duty of providing suitable food for the little mouths and stomachs of infant fish is most important, and a task of love to the zealous pisciculturist. It is not enough to bring a number of young fishes into existence; the all-absorbing point is suitable food, and this must be, at first, of exceedingly minute size; and upon this question depends that of suitable locality. It is undoubtedly true that the presence of sea-weed growth is necessary for the production and growth of most animal organisms; algal growth not allowed to run to excess by an unlimited supply of light is desirable. In large artificially constructed ponds to which copious supplies of sea-water have access the natural conditions would in a great measure yield, by the development of various living creatures, large supplies of food, if the pond was not too crowded. I have seen the ill effects, in the case of trout, of crowding young fish together without a due consideration of those conditions which are absolutely essential to their existence, both in respect to locality and food. As to the shoemaker there is nothing like leather, so to sea fishes there is nothing like *Crustacea*. After a growth of algæ has established itself on the stones and rocks of a sea-pond, a quantity of the larger kinds of sea-weed, *laminaria* and *fuci* should be gathered as quietly as possible, so as not to disturb the swarms of entomostraca which harbour amongst the ponds; these should be conveyed to the fish-pond and shaken in the water, when the entomostraca, annelids and other creatures would be set free, and hide themselves amid the vegetation of the pond; crabs, lobsters, and other *decapoda* might be introduced here and there with a view to a production of the zoecal or larval forms, which are excellent food for so many kinds of fish. Artificial food may be given, as hard-boiled egg pressed through a sieve, or chopped up liver. In Japan, where the Imperial Government are carrying on a complete system of fish-culture, young-fish food, owing to the difficulty of obtaining lungs and livers, is made of a mixture of the chrysalides of silkworms and wheat-flour, on which the fish do well; the former are ground up in a coffee mill, mixed with an equal weight of flour, boiled fifteen minutes, and then allowed to cool; it is then passed through a wire sieve, and is ready for use. Sekizawa Akekio, who contributes a paper on "Fish Culture in Japan," printed in the Report of the United States Fish Commission, has used this food for three years, and says that the fish thrive on it. The confection has been analysed, and has not been found to differ a great deal from meat; it contains a large percentage of nitrogenous matter and a good deal of fat or oil. We have no silkworm grubs in this country, but I may throw out as a hint that some of our caterpillars, such as the Buff-Tip (*Pygæra bucephala*) which sometimes occurs in enormous numbers and strips the leaves of the elm, hazel and other trees, might possibly do to mix as a conserve with flour;

and we might thus utilise their injurious bodies by causing them to make some amends for their wickedness, in the form of young-fish-condiment.

If vegetable matter be kept in water for some time, the water soon becomes full of microscopic creatures almost invisible to the naked eye, but apparent with the aid of a magnifying glass; these *protozoa* and *protophytes* are very valuable as affording food in an indirect way to young fishes; it is seldom that these microscopic organisms are consumed directly by fishes, but they are eaten by other creatures lower in the scale of creation than fishes, and these creatures are large enough to enter considerably into a fish's diet. In the case of such fish as are provided with sifting gill-rakers, as in the herring family especially, very small creatures, as the entomostraca, are consumed in great numbers even by the adult fish; but the entomostraca are giants compared with many of the protozoa or protophytes, which seldom enter into a fish's stomach directly; but such are consumed, as I said, by the fish feeding on creatures which have themselves swallowed this infusorial food; such forms too are largely taken in together with the mud or ooze which many fishes swallow; but for young fry such microscopic forms of life, as they swim about in the water, must not be deemed as constituting their food, as many people suppose. Young fish-fry would pass infusoria with the water through the gill apertures, and would starve, though the water was discoloured from the abundance of such microscopical infusorial life. But suppose that we have been very successful in rearing a quantity of young fishes from artifically impregnated eggs, the question then is what shall we do with them? We know what to do with trout, carp, perch, and many freshwater fishes; we keep them in stews and feed them, and when they are large enough we turn them out to shift for themselves in our rivers or millpools or lakes; and we may be certain that a great many will live and grow, and in due time become parents of a lot of other little fishes like themselves, and that we shall see them again. We can watch them, tell the growth such a lot of fish have attained within a given period, how some which have had access to abundant food have increased amazingly, how others, precisely the same age, have added but little to their size, during the same period, because from being too numerous in a small stew. There was not enough food to increase their growth. But what shall we do with our young sea-fishes, when they have reached a size at which they may be supposed to be able to look after themselves? Mr. Oldham Chambers, in his paper on the Artificial Propagation of Sea Fishes suitable for Food ('Fish and Fishing,' p. 190), says: "If by the aid of fish-culture, millions of eggs are artificially hatched off, . . . and their eggs distributed along our coasts to places specially selected for the purpose, free from the disturbing influences of wind and waves, who is there that can foretell the result to our fisheries in the future?" I confess I am not so sanguine of any happy effects resulting from the distribution of ova into specially selected places, such as this writer so beautifully pictures to himself. Where shall we find such places along our coasts, free from disturbing influences of wind and waves, in which we could place the ova of cod or any other non-anadromous fish? Every part of our coast, even in the case of those parts most free from the disturbing causes mentioned, is always occasionally influenced by atmospheric or tidal influences; and fish ova, when so near the shore, would stand a much worse chance of surviving than if they were far away on the surface of the wide sea. Similarly, if we turn our young fry into such places, I think they would have but little chance of surviving. We naturally look for profits; we expect that "what we have laid out will be paid us again." Shall we add to the sea's stock by such apparent additions? shall we see again as grown fishes those which, as ova or fry, we have consigned to shore water? In the case of all non-anadromus fishes, whose habits do not lead them to seek again those localities where they have been bred or localities similar to those where they have been bred, I cannot anticipate any appreciable good result in this way. Mr. O. Chambers thinks that cod would probably revisit those places where they had been born. This seems to me very improbable. Cod, like other non-anadromous fishes, must wander in search of food, and must go where that food is most abundant. They hardly ever ascend rivers [*see* Cod-fish]; they seek such suitable spawning ground as is convenient in the neighbourhood of the locality at which, in search of food, they have arrived.

The whole notion of adding to our stock of sea fishes, as they occur round our coasts, by artificial propagation, with a view to multiply that stock and so possibly lower the price of fish to the consumer, is, I believe, an outcome simply of an unreasonable panic—a fabric of the brain, based on a false conception of the grand economy of nature—upon a want of appreciation of those vast and diversified causes which operate so beneficially in producing, nourishing and developing the various forms of life which populate our seas. These remarks appertain only to non-anadromous species of fishes; with anadromous kinds the case is different; they would probably revisit their former birth places; we should see them again; they could be to some extent localised; they enter rivers, and for a time at all events thrive and grow in fresh water and this leads me to the next question proposed.

CAN ANY SEA FISHES BE INTRODUCED INTO FRESHWATER RESERVOIRS WITH A PROSPECT OF SUCCESS?—Here, I think, an answer may be given in the affirmative. Basse, grey mullet, soles, and flounders are fishes which naturally frequent our estuaries and rivers, up which they sometimes will ascend for a great many miles, even quite out of the reach of tidal influence. Yarrell mentions that basse have been retained with success in Mr. Arnold's freshwater lake in Guernsey, and Dr. McCulloch has vouched for the superiority of flavour obtained by the change. We have already seen that the luxurious livers of ancient Rome quite disdained a basse unless it were captured in the Tiber, between two bridges, somewhere. Whether they would breed in freshwater ponds has not, I believe, as yet been ascertained, but as a fish that, with plenty of food, will grow fat, and form a convenient adjunct to the table; as one that would give excellent sport to the angler and fly-fisherman; as a handsome, bold, sprightly-looking fish, and as one that has proved itself hardy in confinement, the basse may safely be recommended as an introduction into freshwater ponds, when other more highly prized fish, as trout, are not kept in the same pond. Being a very voracious fish, the basse might be allowed to compete with our strong and equally voracious—but much less active—pike, or with perch, or indeed with large trout. It could be occasionally supplied with garbage, as the gills and intestines of other fishes.

The grey mullet, another fish cultivated by the Romans, would certainly succeed; experiments have been made with this fish, and not only does it grow and thrive better than when in the sea, but has been known even to spawn in fresh water [*see under* Grey Mullet]. The sole has also been tried with a freshwater residence, and the experiments hitherto made favour the idea that it would do well in ponds and rivers [*see* Sole]. It is susceptible of cold, but in the severe weather of winter it would bury itself in the mud and sand, and so protect itself. It is a fish, moreover, that would find a good deal of food from the oozy or muddy bottom of the fresh water, such as small annelids, *nais*, &c., the larvæ of various insects, as *ephemera*, *sialis*, *dyticus;* young crayfish and other crustacea, as the freshwater shrimp, *gammarus*, *asellus*, &c.; various entomostraca, as *cyclops*, *daphnia* and *cypris*. For soles one would be inclined to recommend large pools into which abundance of fresh water is being constantly brought by small streams, with mud and sand, and pebbles in parts of it, at the bottom. Mill-pools are especially adapted for fish-culture, on account of the constant flow of change of water in and out. Of the flounder I need say little; it is a very decided anadromous fish, would thrive and improve in flavour by a residence in fresh water, and moreover is now a favourite fish for anglers near some towns, who, as in the neighbourhood of Warrington, flock to rivers in numbers to enjoy a day's fishing and a happy peaceful holiday.

The young of these fishes would bear transference readily. Even the valuable sole would admit of little difficulty of transfer in its young state, when from four to six inches in length, for I have kept them for a great many hours out of water, and find them tenacious of life to an extent greater than is generally supposed. Experiments, however, are needed in this matter before any definite prospect of success can be expected; and it is my intention, if all be well, to make some experiments this year, with a view to ascertain the effects which a change from sea water to fresh will produce in some of the above-named fishes.

CAN THE PRESENT MODES OF CAPTURING SEA FISHES BE INCREASED WITHOUT FEAR OF DIMINISHING THE NATURAL SUPPLIES OF THE SEA?—This is one of the most important of all the questions asked, because upon the true answer to this question much depends in connection with the future supply of fish food to the increasing population of this country; various other questions arise which are, more or less, involved in a consideration of this one. A cry is heard on all sides that we are over-fishing and exhausting, in some instances, the natural supplies of the sea—that soles are becoming so scarce, by a wanton and mischievous destruction of the young ones, that by and by, unless legislative and prohibitive acts interfere, the sole will become almost extinct, and we shall ere long have to go to the British Museum to see a specimen of this famous fish! Let us consider the case of soles. Their high price, now continuing for some years past, has attracted considerable and well-deserved attention, and not a little natural grumbling on the part of the consumer. Men and women look back to years gone by, when this most generally esteemed of all our sea fishes could be purchased as low as 6*d.* or 8*d.* per pound; and now so low a price is never heard of. It is seldom that the purchaser can buy a sole under 1*s.* per pound; often he has to give 1*s.* 4*d.*, 1*s.* 6*d.*, 2*s.*, or 2*s.* 6*d.* per pound. That soles are excessively dear is an undoubted fact, and a great many people have at once jumped to the conclusion that the high price is entirely and only due to the great absolute scarcity, and that the scarcity has arisen from over-fishing, and especially e capture of immense quantities of young soles, too small for food, as taken by the trawl, the shrimp-net, and the stow-boat net, &c. The question, "Are soles diminishing in numbers?" is certainly one of national importance, but it is only a part of the whole matter involved, one interest in the various interests concerned in our sea produce and sea fisheries. The sole must not rule supreme as the *only* sea food-fish or sea food produce; but it is of such undoubted importance as to demand a thorough inquiry into the question of its yearly suffering serious diminution in numbers, owing to unjustifiable modes of capturing it. If there has occurred, and is occurring, such a useless waste and destruction of young sole-life, caused by man's agency, as to lead to a serious diminution of these fish in localities where they once abounded, no doubt it would be the duty of Parliament to interfere, and restrain or curtail such destructive mischief. Is there any just reason to suppose that soles are diminishing numerically in our seas? It must be remembered that the high price of fish cannot of necessity imply anything more than a temporary and comparative scarcity in our markets; and, again, a comparative scarcity in our markets is no proof whatever of an absolute scarcity in the sea, or any diminution of the species over wide areas; for the most common and abundant kinds are sometimes comparatively scarce in our markets; and, once more, the high price to the consumer of our sea fishes is not always and only to be attributed to any real scarcity at all. Those in a trade know the tricks of a trade. But is it a fact that fewer soles are caught now than formerly, and is there any reason to believe in a constantly diminishing supply? The whole evidence which bore on the question of a diminishing supply of our sea fishes, contained in the "Report of the

Commissioners appointed to inquire into the Sea Fisheries of the United Kingdom," in 1866, distinctly negatives the supposition of a decreasing supply. The Report of that Commission, composed of Professor Huxley, Mr. Caird, and Mr. Shaw-Lefevre, is an admirable exposition of philosophic reasoning, and is remarkable for the diligence and fairness which it displays. From inquiries I have diligently made myself at various parts of the coast of England, there seems to be no cause whatever for believing that over-fishing is threatening the diminution of the natural supply of soles. Sometimes very large takes are made, sometimes very small ones. Fishing is proverbially uncertain as to success. Soles are great wanderers, and they are not a "school" fish, like plaice and haddock; and only under exceptional circumstances, as when they throng in countless multitudes to the deep waters in severe weather, are they caught in prodigious numbers; they are loosely and not compactly associated, and wander about, and it is more or less a matter of chance as to when and where the trawl falls in with them. The very fact of their being generally caught in immense numbers in such deep places as the "Silver Pits" of the North Sea, every year when the winter is severe, is itself a witness of their abundance somewhere, though perhaps distributed over rather wide areas. Let us multiply our fishing smacks and fishing gear, and occupy our business in wider waters, and we shall multiply our chances of successful captures. I do not think there can be a better instance of the proof of the non-diminution of soles by over-fishing than afforded at Torbay. The area over which the Brixham trawlers work is by no means a large one. They seldom go out farther than a distance of twenty miles, and often not nearly so far. Trawling has been going on in Torbay for more than 100 years—it is one of the oldest trawling stations in England—and there is no apparent diminution in the number of soles taken, comparing year with year for a period of time. Some of the Brixham fishermen told me they thought there were as many soles in the sea there as ever there were; but, as they would say, "We cannot always drop across them." But with respect to the destruction of young soles by meshes of a small diameter, it is right to ask, "What is the use of catching that which is useless? Why destroy a lot of little fish that would, if left alone, some of them at least, grow into big ones?—while yet not more than a few inches in length they are worthless." All persons would perhaps agree that it is not desirable that such fish should be taken, but that they should be left to take their chance and grow to a marketable size. But here comes the difficulty which would attend prohibitive Acts of Parliament, enforcing a close time for soles, or meshes of a certain size. Young soles are caught in large numbers by the shrimpers in spring and summer. So, if prohibition stops the shrimpers from catching young soles, it also stops them from catching shrimps, just at a time when the shrimp business is brisk and profitable; so that such prohibition would seriously interfere with a class of men who are engaged in an honest calling—one which is profitable to themselves, and a source of the introduction into our markets of a very delicious and nutritive food. The advocates of prohibitive legislation would rob Peter directly to pay Paul indirectly. Seeking to establish such interference, they seem to say to us: "If you are good boys for a few months, you shall probably have at the end of that time cheaper soles for dinner; but in the meantime you must go without shrimps for tea." *

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* It is almost affecting to think of the soles and the shrimp sauce thus retiring from the festive board together!

I am, moreover, very much disposed to think that, by the shrimpers at least, but little real injury is done to young soles. I have been out in shrimping boats, for the purpose of catching both shrimps and young fishes, or other natural-history objects. Certainly the net brought up a considerable number of soles of a small and useless size, also young dabs and flounders. But a great number of these soles, by far the larger proportion, were not the young of the common commercial sole, but those of the "little sole" (*Solea minuta*), which never grows to any marketable size. As a rule the Southport shrimpers, at all events, return the young fishes into the sea, unless specimens are required for the Aquarium there; indeed everything except the shrimps is thrown overboard. Neither are the young of the commercial sole injured by the nets to any extent; they do not strike into the meshes; and in this respect the young sole resembles the older sole, which will generally "strike"—as the trawl surprises them they retire and try to escape forwards, and they would do so in the trawl, were it not provided with the wing-purses into which they go, and out of which there is no escape. But, oddly enough, the *Solea minuta* is a "striker," and tries to push through the meshes, in consequence of which numbers get firmly fixed, with body sticking out of the net, sometimes making it almost bristle with the numbers. Such, when returned back to the sea, die from the pressure they have received; it was rare that I had to pick out of the meshes a young sole proper. I am of opinion, therefore, that little, if any, serious damage is done to young soles by the shrimpers. Some of the North Sea trawlers are in favour of a close time for soles, for the months of May and June, when they spawn; at this time soles are soft, and not in their prime by any means; but a close time for soles would not be practicable, because trawling must either be stopped altogether during these months, or soles must be returned again to the sea. To stop the influx of an important article of food, in the shape of various other kinds of fish, by the adoption of a prohibitive close season, in order to do something which might possibly increase the numbers of one particularly favoured kind, is a measure that condemns itself as manifestly unfair and pernicious. To return to the water a number of soles full of spawn caught in the trawl would be useless, as most of the soles in that condition would undoubtedly perish; for, though young fish are uninjured the short time in which a shrimper's net is in the water, fish full of spawn for some hours in the trawl would not be able to survive.

But the whole proposal, either to stop the capture of adult soles during the spawning season, or the fry by the hose or other nets of the shrimpers, rests on a mistaken notion altogether, as I before mentioned. When one bears in mind the enormously multiplying powers of sea-fishes, as evidenced by the thousands or even millions of eggs which one female contains, is it not at once palpable that great destructive agencies of some kind are necessary to keep them in check? The natural destructive agencies always at work, and acting for the welfare of the survivors, are such as are wrought by the fishes themselves —the stronger feeding on the weaker; by other active inhabitants of the deep, as porpoises; by birds and possibly by other creatures. When we consider the amazing fertility of the sea in living creatures, and the equally amazing amount of food they require, we cannot help seeing that the natural destructive agency at work is incalculable in degree. Besides this natural beneficially-destructive work wrought by living creatures of the sea and air, we frequently notice other destructive work in occasional operation in the shape of physical and cosmical phenomena, such as storms which strand incalculable numbers of young fish or ova on the shore, or as a hot sun which destroys young fry, left in the shallows by the retreating tide, by millions. Artificial destructive agencies are of course those which are adopted by man for the capture of the fishes. When therefore we reflect on the prolific powers of the fish, the incalculable quantity of fish food which they must require, the hundreds of miles of area occupied by many of them, the comparatively small areas where man works for their capture, we cannot come to any other conclusion than that the destructive forces caused by man against the fishes of our seas are utterly inappreciable as contrasted with those continual natural agencies of destruction which are for ever going on, and always, as a rule, for the good of the whole; and therefore we have no hesitation in answering the third question proposed, in the affirmative, and saying: "Let us increase, or render more efficacious, our present modes of capturing fishes, and we shall increase our food supply to an extent commensurate with such increased or improved machinery, and still shall not cause any sensible diminution in the natural quantity of those supplies."

WHY ARE FISH, ESPECIALLY SOLES, SO DEAR?—If there is not, as I have endeavoured to show in a brief consideration of the previous question, any reason to attribute the high price of soles to an absolute diminution of their numbers in the waters of our seas, we must look for an explanation of this very true but, to the consumer, unpleasant fact in some other direction. The high price is owing mainly to the enormous and still increasing demand for soles, and to the comparative scarcity in relation to such demand; and, as such demand is still further likely to increase with an increasing population, there is every reason to suppose that, unless our appliances for capturing them are increased, a still further rise in the price will mark the commercial value of this fish. When we consider the excellent quality of the flesh of the sole, the various convenient sizes to which it runs, some being small and just enough for one person, others just suited to two or three, and others of large size enough for a tolerable-sized party; when we take into account the readiness with which a sole is prepared for the table at a few minutes' notice, and the different ways in which it is cooked; when we consider that it is not only the general most favourite fish of nearly all people in health who can afford to buy it, but that, from its light, pleasant and nutritious qualities, it is peculiarly the invalid's fish, we shall cease to wonder at the constant and ever-increasing demand for it. In former years, before our country was intersected, as it is now, with railways, there was no great demand for them in districts far away from the coast, so that, whilst our railways have rendered soles familiar in places where they were not much known before, they have helped to increase the price by bringing them quickly within the reach of multiplied thousands, and have made more and more extensive the demand. But one especial reason for the high price is the fact that in London and our other large towns there is enormous wealth, and the rich people will have soles, cost what they may; in consequence of this will-have-at-any-price system, the retail dealers put the highest possible figure upon them, and a very profitable margin is thereby allowed to the wholesale merchant. Soles are more eaten in London than any other fish, and it is from London that the retail dealers obtain their daily quotations, by which they fix the price per pound in other parts of the country. Moreover, during the summer season a considerable supply is sent daily from the London fish market to Paris. The Commissioners in 1865 drew attention to the great disparity of price between the wholesale and the retail trades. "The buyer of fish in the West End of London finds that, on the average, his fish costs him more per pound than his mutton and his beef. And, when inquiry is made, the salesmen at Billingsgate readily admit that the retail dealer gets an enormous profit on the small quantity of fish he disposes of. It might be thought that the competition of trade would rectify any demand for excessive profit, but in this case it does not seem to have that effect." (*Report*, p. xvi.) Soles are not a shoal or "school" fish in the same way that herrings, pilchards, plaice, haddock, &c., are, as mentioned above, and their captures are uncertain; the continued stormy weather that for some two or three years past has been prevalent all round our coasts of course must make fish of all descriptions scarce; not only do the trawlers refuse to venture out to sea in very bad weather, but it is not possible to work the trawl properly when the waves are very high, so that this cause has the last few years operated seriously in the fish supply of our markets. The high price of some fish considerably affects the price of others whose average price is by no means great; there is more demand for what is brought to the market, and in consequence the retail dealers at head-quarters can put their own figure upon the fish. It is the interest of all concerned in the trade, retail and wholesale, to keep up the prime fish at the highest possible figure, because from the sale of the prime fish—soles, turbots, brill, and cod—they make their chiefest gains. Let the consumers refuse to give exorbitant prices for soles, and the evil will rectify itself. But as long as the wealthy people of London and other towns love to vie one with another in the ostentatious display of plover's eggs at 2*s.* 6*d.* and 5*s.* apiece at a wedding breakfast, just as these dainties are coming into season; and as long as they will spend 10*s.* apiece on "boned" ortolans, so long will there be no difficulty in supplying such expensive mouthfuls by those who deal in them. The luxurious and extravagant people of London are, it is to be feared, in this respect on a level with the same class of people in the days of the later Roman Empire.

Of course, in London, the monopoly of one great fish-market is one of the chief, if not the chiefest, reasons for the high price of our fish food. And, as was said just now, the London price fixes the price almost all over England. The monopoly of Billingsgate has much to answer for. Let the public weigh well the opportune words of the *Daily Chronicle* of April 30th. Speaking of the forthcoming Fisheries Exhibition, it says: "It is difficult to understand how any great good can come of it, unless it leads to the provision of greater facilities than we at present possess for the reception and distribution of the products of the fishermen's labours. We have but a single fish-market for the whole Metropolis; and that it is totally inadequate to the requirements of a population of four millions of people is notorious. Yet it is to the interest of those who control the London fish supply that Billingsgate should continue to be the sole emporium for the wholesale trade. Every attempt that has been made to provide additional market accommodation has been frustrated by the Billingsgate ring. The experiment which the Baroness Burdett-Coutts made to establish a fish-market in the fine building erected at her own expense in Bethnal Green failed simply because the Billingsgate monopolists were too powerful to admit of its success. The ring are omnipotent, because they have at their mercy the fishermen themselves, who are largely indebted to the Billingsgate merchants for loans advanced to provide for the purchase of fishing-boats. We fear that a second market will never succeed unless the promoters of it are prepared to compete with the Billingsgate men in the banking as well as in the fish business. We trust that the Conferences to be held in connection with the forthcoming Exhibition will be able to devise means for breaking up the Billingsgate monopoly, and providing market accommodation for a daily supply of fish adequate to the wants of our ever-increasing population."

With our present means of capturing fish I do not think it probable that we shall ever see the day when we shall be able to obtain the prime kinds at a moderate cost. The inexhaustible fertility of our seas (blessed in this respect as no other nation in the world is), contrasted with the comparatively small proportion of fish which finds its way into our markets ; the trawling grounds which, generally speaking, are only inadequately worked or not worked at all—all are points which call for attentive consideration. There is plenty of food in our waters, but not adequate means for bringing it plentifully enough to the people. The harvest of the sea truly is great, but the labourers are few. How is the staff of our seafaring fishermen to be increased, boats to be multiplied, and mechanical means of capture to be strengthened ? What do we expect from the sea's produce of inexhaustible fish-food ?—wholesome food at a moderate price to the consumer, and a fairly-remunerative price to the supplier. Shall we depend on limited liability companies ? They would increase the abundance of fish-food, and to a certain extent lower the price ; but companies look to large dividends for their shareholders ; it is their business, it is with such a prospect in view that companies are formed. It would be their object to demand the highest possible price. Would it be possible for the Government of the country to take up the matter on its own responsibility, not by any means in antagonistic opposition to existing companies, but as an additional means of providing food for the people? Would it be possible to establish a Royal Fishery Service under the control of the Government with such an end in view? Such a service might be in connection with the Works and Public Buildings Department and combine the subject of Harbour Protection for our vessels so much needed on various parts of the coast. It might find work for the Irish inhabitants of the coasts, who from sheer poverty and necessity are prevented from providing themselves with fishing gear and catching fish which at present they see in their bays and inlets playing before them, and which seem to say derisively, "Don't you wish you may catch us?" Let us mark well the last two Reports of the Inspectors of the Irish Fisheries, for 1880 and 1881. What do we find but the same story constantly recurring—"that fish of every description could be taken in large quantities if the fishermen had the means, such as boats and gear." That "large shoals of mackerel appeared, but there were no adequate means to capture them," and so on almost *passim* in these two Reports. Cannot something be done by helping these Irish fishermen—to their credit be it spoken that, according to the "Reports," their conduct in all the districts almost without exception is "good and orderly." Let us look at the Welsh coast; with the exception of Tenby and Carnarvon there is no trawl-fleet, I believe, anywhere, and these two stations are fished from English stations by English fishermen. The fish in the great bay of Cardigan are, it is true, trawled for by Liverpool smacks, but line fishing and drift-net fishing produce scarcely anything, so that on the whole the fish in that wide expanse of water enjoy almost a perpetual holiday.

Only one other matter I will mention. Whatever difficulty there may be in the way of any active Government help in the line indicated, I think there can be and ought to be none in this, viz.:—

The desirability of establishing centres at different parts of our coast for experimental researches into the natural history of our sea fishes, under the control of the Government, with buildings and reservoirs fitted for scientific purposes, under the direction of qualified naturalists.*

## THE BASSE (*Labrax lupus*, Plate III.).

### FAMILY *Percidæ.*

Form of body usually oblong; scales ctenoid or cycloid; branchiostegals six or seven (in *Percilia*, west coast of North America, five to six); pseudo-branchiæ present; lateral line generally continuous; the opercles usually serrated; no bony stay for the preoperculum; teeth villiform, with or without canines; teeth on the vomer and palatine bones; eyes lateral; dorsal fin spinous and soft; ventrals thoracic, with one spinous and four or five soft rays; swim-bladder generally present, simple; pyloric appendages usually few in number.

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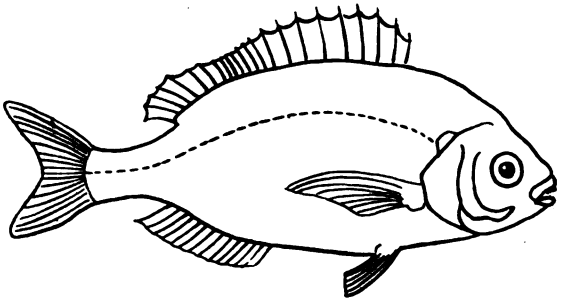
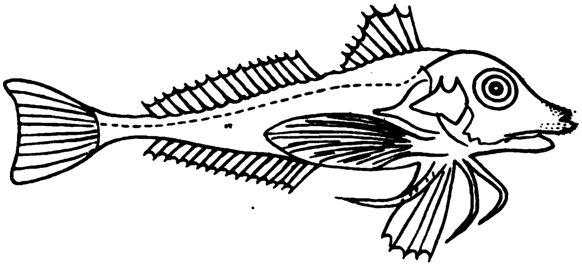
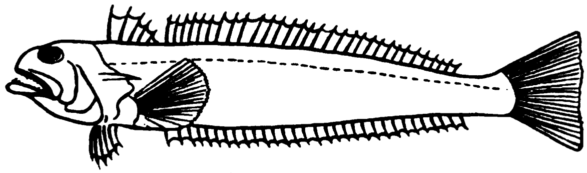
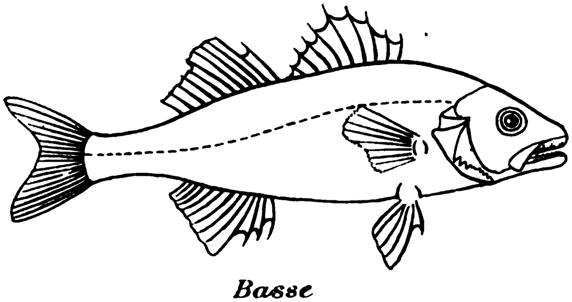
* Will not the Government of this country learn a lesson from America, Sweden and Norway, and take some interest in scientific pursuits and encourage such pursuits by State aid? The Americans have now a floating hatchery on a well-constructed steamer, the *Fish-hawk*, in which numerous experiments can be carried on. It is with science in England now as it was with honesty among the Roman people in the time of Juvenal, "laudatur et alget."

Plate III.


*Black Sea Bream*


*The Piper*


*The Greater Weever*


*Basse*

GENUS *Labrax.*—"Seven branchiostegals; pseudobranchiæ developed; all the teeth villiform, without canines; teeth on the palatine bones and on the tongue; two dorsals, the first with nine spines; anal fin generally with three; operculum spiniferous; preoperculum serrated and with denticulations at the lower limb; preorbital entire; scales rather small or moderate; number of pyloric appendages, few (4–5)." A marine and river genus of perches found on the shores of the Arctic regions, and in the rivers and along the coasts of North America, extending in Europe to the Mediterranean and Egypt.

*Λάβραξ.*—Aristot. H. A. i. 5, 2; iv. 8, 10; viii. 20, 5, &c. Ælian, i. 30; x. 2; xiv. 22; Athenæus, vii. 14; Oppian Halieut. 130–140.

*Lupus.*—Pliny, ix. 16, 17, 53; Gesner de Aquatil. pp. 506–515; Willughby, iv. p. 271; tab. R, 1.

*Perca.*—Artedi, Gen. Pisc. p. 41; Descript. Pisc. p. 69.

*Perca labrax.*—Lin. Syst. Nat. i. p. 482; Flemming, Brit. Am. p. 213; Jenyns' Brit. Vert. p. 331; Pennant, Brit. Zool. iii. p. 348, pl. 60.

*Labrax lupus.*—Cuv. & Valenc. ii. p. 56, pl. xi.; Yarrell, i. p. 8 (edit. 2nd); Couch, Fish. Brit. Isles, i. p. 189, pl. xl.; Günther's Catalogue, i. p. 63; Introd. to Study of Fishes, p. 377; Day, Fishes of Great Britain and Ireland, pt. i. p. 8, pl. ii.

*Geographical distribution.*—The bass occurs in the Mediterranean, and on the coasts of Portugal, France, and England; it is common in the summer months on the coasts of England and Wales. In Scotland it is said to be rare to the north of the Firth of Forth, and there is no record of its occurrence in the Orkney and Shetland Islands. It is probably found around Ireland, but its numbers decrease northwards; it is said to be not numerous along the Irish coasts, but probably this opinion arises from the comparatively limited fishing carried on in Ireland. It is more plentifully taken on our southern coasts, a warm temperature being apparently best suited to its growth and general requirements.

*Habits.*—Bass generally swim in shoals and frequently ascend rivers to a considerable distance, sometimes far beyond tidal influence; they are not often seen during the winter months, and probably retire to deep and warmer water. In the spring and summer months they frequent the vicinity of harbours, piers, &c., where they find abundant food in the young fry of mackerel, pollacks, herrings, &c. Strong, bold and voracious, the bass affords excellent sport to those fond of sea fishing, but being well skilled in artful devices the fish often eludes efforts to capture it.

*Food of.*—Fish of various kinds and small squids, of which bass is particularly fond, crabs and other crustacea. Couch says it is partial to the *Onisci* which are to be found on the rocks, and that it hunts along the coasts during gales of wind for these creatures which are washed off by the waves. Bass will no doubt eat offal and things not nice, but as a rule they prefer living active prey.

*Spawning.*—The spawning time appears to be in the spring and early summer months, as is so frequent amongst many of our sea fishes; they are said to deposit their spawn near the mouths of rivers, but I am not aware whether any record exists as to the mode of deposition, whether on the surface of the water or at the bottom. According to Thompson ('Nat. Hist. of Ireland,' iv. p. 71), the ova of the female, which are extremely numerous, are smaller than the smallest clover seed: he examined a specimen weighing fourteen lbs. taken in the month of March, and brought to the Belfast market. On the continent the bass is said to deposit its spawn twice in the year. Aristotle says, "Fish as a rule breed only once in a year; but the *labrax* is an exception, for this alone of the kind called *chyti* (χυτοί)* breed twice a year, but the latter produce is much weaker" (H. A. v. 9). The growth of the bass is probably rapid according to the supplies of suitable food with which it meets; the very large stomach of the bass betokens great capabilities in this respect. Specimens of four, five, seven and ten pounds in weight are often to be seen in the markets; but they are known to attain the weight of twenty or twenty-eight pounds occasionally.

*Modes of capture.*—Bass are sometimes taken by the trawl, but usually by hand-lines baited with long worms, sand-eels or pieces of cuttle-fish (squid). They are also caught by trolling with an artificial bait of india-rubber in the shape of a large twisted worm and hook. Salmon-flies cast in the ordinary way of salmon-fishing are sometimes used, and give exciting sport. Thompson says that in Belfast Bay bass are generally caught in the nets with salmon, sea trout, and mullet. According to Mr. Dunn, of Mevagissey in Cornwall, who has paid great attention to all matters relating to fish, the seine-net cannot be employed successfully unless the net be drawn on to the shore, for the bass are so cunning that they dive under the foot-rope when the net is on ground at all rough.

*Quality of flesh.*—When eaten fresh from the sea the bass I consider to be very fair eating, the flesh is white and pretty firm in texture; it is not so good the second day after capture, as it becomes somewhat oily and has too marked a flavour. It is best when boiled.

*Commercial value.*—This fish does not hold a very high place in a marketable point of view; it is not, however, caught in sufficient numbers to bring it under general notice as a food fish. Specimens find their way to Billingsgate, Birmingham, Liverpool, Plymouth and other towns, and generally fetch about 8*d.* per lb.

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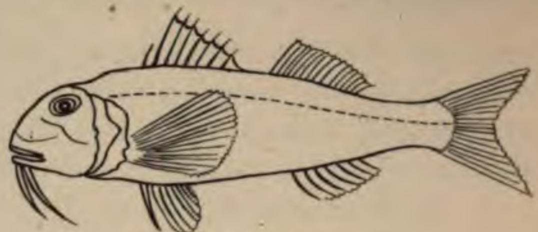
* The Greek word means literally "poured forth," hence "abundant," applied to fish which swim in shoals and are caught in a net.

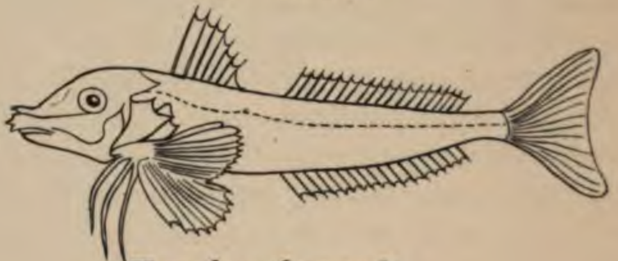
*Classical allusions.*—There seems to be no doubt that the bass is the fish known to the ancient Greeks and Romans by the names of *labrax* and *lupus.* The Greek word evidently refers to the voracity and impetuosity of the fish, from a root meaning "to be violent" (see Athenæus, vii. 86). The Latin *lupus* of course denotes its wolf-like character. The bass was generally held in great repute among the ancients as an article of food; but it was chiefly those that were taken in fresh water that were preferred, the sea-caught specimens being but little esteemed. Sewer-fed specimens were considered the best, and the luxurious would give exorbitant prices for them. Bass are certainly fond of frequenting the neighbourhood of drains, but I suspect it is rather for the sake of the small fry they meet with there than for the actual offal or filth. The cunning of the bass in eluding capture is referred to by the ancient Greek and Roman writers. Aristotle calls it the "wisest of fish," though I think that the grey mullet beats the bass in this respect. Ovid speaks of this fish getting under the sand to avoid the net:—

> "Clausus rete lupus, quamvis immanis et acer,
> Dimotis caudâ submissus sidit arenis" (Halieut. 22);

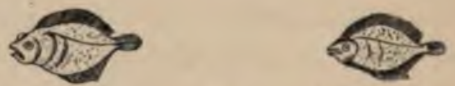
and also refers to its habit of shaking from its jaws the hook that would capture it (38–41.) Pliny (xxxii. 2) tells the same story. In a mosaic group of fish disinterred at Pompeii, and now said to be in the Museum of Antiquities, the *lupus* is figured.



*Red Mullet*



*The Grey Gurnard.*



*Young Turbot caught at surface of the sea,*
*from specimens in the possession of the author.*
*(nat. size)*

*The drawings, which accompany this essay, are given merely as suggestions of the way of representing a few objects connected with the general subject. Details remain to be filled up, if required, and further drawings added.*

*A popular "Handbook of our Commercial Sea-fishes" is much needed.*

*The few outline figures of fishes are given simply as specimens to show that outline drawing is for all practical purposes sufficient as aids to the determination of species.*

*In confinement.*—The ancient Romans kept these fish in their piscinæ; but I can find no mention of their having bred there. They have been successfully kept in freshwater aquaria by modern experimentalisers, and the quality of the flesh is said to become better by the change. For myself I should prefer one taken from the sea.

*Names.*—In our own country the bass is known by the names of the sea-dace, *salmon-bass, white salmon, sewin;* Mr. Day gives *gape-mouth* for Scotland, and *white mullet,* or *king of the mullets,* for Belfast. The Welsh *draenog* is also used for a hedgehog; the word means "full of bristles." The name of *basse, barse, brasse,* and *bream*—all radically the same—is to be referred to the Anglo-Saxon word *bærs-perca, lupus,* but the root of the word is unknown.

*General description.*—Body more elongated than in the common perch, and bears some resemblance to that of a salmon; hence the name of white salmon referred to above. Length of body equal to about four and a half of the height: posterior margin of preopercle strongly and sharply serrated; lower limb with three more, blunter teeth; lateral lines nearly straight; back and sides grey or greenish grey, sometimes dusky blue; under surface silvery white; tail forked. Young specimens are marked with small dark spots over the body. This is the spotted kind mentioned by Columella. (See Introduction.)

## THE RED MULLET (*Mullus barbatus*, Plate IV.).

### FAMILY *Mullidæ.*

Body somewhat elongated; profile of the head more or less parabolic; eyes moderate in size, and lateral; mouth small, with a lateral cleft; branchiostegals four; pseudo-branchiæ present. Dorsal fins two, and separated; anal similar to the posterior dorsal; ventrals, with one spine and five rays; two long stiff barbs under the chin; lateral line continuous. Teeth feeble, and variously placed. Air-bladder, when present, simple; scales large, minutely and finely ctenoid, often deciduous.

GENUS *Mullus*.—The characters as those of the family. Teeth in the lower jaw and on the vomer and palatine bones; none in the upper jaw. Mediterranean and coasts of Temperate Europe, Madeira and the Canary Islands.

Τρίγλη.—Aristot. ii. 12, 13; v. 9, 1; v. 25, 3; vi. 16, 3; viii. 4, 1; ix. 25, 7; Ælian. ii. 41; Athen. vii. cap. 125–127.

*Mullus*.—Ovid, Halieut. 123; Pliny, ix. 18, 51; Martial, x. 30, 31; Willughby, p. 285.

*Trigla*.—Artedi, Gen. p. 43.

*Mullus barbatus*.—Lin. Sys. Nat. i. p. 495; Yarrell, i. 36; Günther's Catal. i. p. 401; Introd. Study of Fishes, p. 404; Couch, Fish. Brit. Isles, i. p. 217, pl. xlvii.; Day, Fish. Gt. B. and I. part i. p. 22, pl. viii. (See Plate III.)

There seems to be no doubt that there is but one species of European mullet, and that the surmullet or *Mullus surmuletus*, generally considered a distinct species, is merely a variety of the barbatus. Some have thought that the *M. barbatus* is the male, the *M. surmuletus* the female. According to the views of Professor Steindachner, who examined as many as 75 specimens and found great variations in the profile of the head, *M. barbatus* and *M. surmuletus* represent the extreme limits of variation of one single species. For all practical purposes they may be so regarded.

*Geographical distribution*.—In general terms this has been mentioned above. The most common mullet of the Mediterranean appears to be the *M. barbatus;* the larger striped variety or *M. surmuletus* is common in the North Atlantic, and is that which is generally found in more or less abundance off our own coasts. It is certainly the variety which the trawlers of Brixham and Plymouth take in great abundance, as I can myself testify from personal observations at these places. The red mullets are not found in any quantity except on the south coast of England, and Devonshire and Cornwall may be regarded as their head-quarters. A few instances are recorded as having been taken in Scotland and Ireland; but such cases are exceptional and very rare.

*General habits.*—Red mullets are of a roving disposition, and swim in shoals; sometimes they swim near the surface, but usually they frequent the deeper parts of the water, and take their food, as the presence of the barbules would indicate, from the ground. In the winter time they retire from the coasts into deeper water. In the summer the red mullet occasionally approach quite close to the shore and rocks, and a few are caught there, but at Brixham the trawlers generally have to go several miles away, in the direction of Start Point principally. They are taken all through the winter, but not in such large numbers as in the summer.

*Food of.*—This consists principally of crustacea and worms, both of which I have found in their stomachs. The ancients were mistaken in attributing to the red mullet filthy habits in its diet. I know of no fish which, when opened, gives forth so little unpleasant odour, and one can partake of the "woodcock of the sea" without any apprehensions of swallowing the stomach of foul feeders. The fish are, no doubt, to a considerable extent, guided in the choice of their food by the long muscular cirri, or barbules, of the under jaw. The importance of these organs in fishes which are supplied with them is very considerable; doubtless they compensate for imperfect vision at great depths. Those who have noticed the sturgeon taking its food cannot help being impressed with the importance of these tentatular organs. Directly the sturgeon's barbules come in contact with the worms at the bottom of the aquarium, the sucker-like mouth of the fish is suddenly shot out and the worms devoured.

*Spawning.*—This takes place during the months of July, August and September, some fish maturing their ova considerably earlier than others. In a female about 11 inches long I have found the ovary to be about 1½ inches long on the 24th August, full of immature ova which are very minute; this would consequently be a late spawner. According to Mr. Dunn, the ova are shed only a little at a time, so that the process extends for some days, or even weeks. Young mullets of about 2 inches in length have been noticed in October. It has not been observed whether the deposition of the ova takes place near the bottom or the surface. Probably the latter will be found to be the case, as in most of our sea fishes. The deposition of the spawn at the bottom is considered by G. O. Sars to be an exception to the general rule. The usual size of the red mullet is from 8 to 14 inches long; but occasionally larger individuals are taken. At Mevagissey one of 17 inches in length has been captured.

*Modes of capture.*—Chiefly by the trawl, sometimes by the seine and trammel when they swim near the surface, which they are thought to do on their migrations from one locality to another. I think it not improbable that the mullet are surface swimmers about the time of spawning.

They are said to be now and then taken with a baited hook.

*Quality of flesh.*—In the opinion of almost all eaters of fish, the mullet stands very high indeed; white, flaky, firm, and free from oil, the flesh is palatable and easy of digestion; the liver is the dainty morsel which gives the peculiarly delicious flavour to the sauce with which it is mixed. The usual mode of cooking is to wrap the whole fish—the gills only being removed—in a sheet of white buttered paper and to roast in a Dutch oven, or to bake for about 20 minutes. The juices are thus retained. A little port wine is a good addition to the melted butter, or anchovy sauce. Mullet always maintain a good demand in the markets. The competition among the wholesale buyers at Brixham, when the supply is short, is very considerable, and large sums of money are sometimes secured by the successful trawler. The decided red colour of the fish is due to the change in form of the pigment cells, produced by irritation when the scales are removed. Formerly the scales were removed from the fish by the hand of the fisherman soon after they were caught; for unless the scales were removed at this time the fish would not have that red colour which custom and fancy have required it to possess. Now manual operation is not so much practised; for the trawl passing over the ground, and rubbing the fish against each other, is sufficiently effective in the scaling process. At Brixham, I was told, hand-scaling was not now considered necessary.

The price of course varies somewhat according to the supply and demand. At Brixham I could get red mullet of 9 or 10 inches in length for about 4*d.* a piece; in London and elsewhere the same fish would sell for 1*s.*

*In confinement.*—The ancients occasionally kept supplies bear confinement well. "Never, however much we may wish it, shall we be able to feed a multitude of mullets in a vivarium, since this kind is very delicate and most impatient of confinement ('mollissimum genus et servitutis indignantissimum'). Only one here and there out of many thousand can bear confinement (claustra patitur); while on the other hand we frequently see in confinement shoals of such sea fishes as the sluggish *mugil* ('white mullet') and the rapacious *lupus* (basse)." Martial also speaks of the difficulty of keeping red mullets alive in confinement:—

> "Spirat in advecto, sed jam piger, æquore mullus :
> Lanquescit? vivum da mare, fortis erit" (xiii. 79).

The red colour of the fish delighted the Romans, and living mullet used to be brought into their feast-rooms, swimming in glass vessels, and were taken out and left to die in the hands of the guests; the supposed barbarity of the thing met with the severe censure of Seneca (Quæst. Nat. c. 17), and later of the French naturalist Lacépède. The custom of cooking red mullet unopened prevailed in ancient times. Ælian (De Nat. Anim. x. 7) expressly mentions it: "Skilful cooks, in order that the bellies of the mullet may not burst open, are accustomed to kiss the fish, which is supposed to keep them entire."

*General description.*—The chief characters which distinguish the *M. barbatus* from the variety *M. surmuletus* are, a less oblique profile of the snout in the former than in the latter, the presence of a number of bright yellow lines or longitudinal stripes in *M. surmuletus*, which the other has not. There are other minor points of difference which I need not refer to. The principal characters of these varieties are thus given by Günther: "*Mullus barbatus:* upper profile of the snout approaching the vertical line;

the upper maxillary reaching beyond the vertical from the anterior margin of the eye. Red, without yellow stripes. *M. surmuletus:* upper profile of the snout very oblique; the upper maxillary reaching to the vertical from the anterior margin of the eye. Red, with three yellow longitudinal lines." These lines are sometimes four or five in number, and sometimes they are indistinct or quite concealed. The *M. surmuletus* appears to attain the larger size, very fine specimens being caught in the neighbourhood of the Channel Islands.

## SEA-BREAMS (*Cantharus lineatus*, Plate III.).

### FAMILY *Sparidæ.*

Body compressed and oblong; pseudo-branchiæ well developed; branchiostegals five to seven; eyes lateral; mouth in front of the snout having a lateral cleft. Dorsal fin single, consisting of a spinous and soft portion; anal with three spines; lower pectoral rays generally branched; ventrals thoracic, with one spine and five rays; lateral line continuous, not extending to the tail-fin; teeth, cutting or conical in front of the jaws, with a lateral series of molars; none on the palate except in genus *Pimelepterus;* bones of the head with a rudimentary muciferous system; air-bladder often bifid posteriorly; scales cycloid, minutely and feebly pectinated.

Herbi-carnivorous fishes in the seas of temperate and tropical regions. Some enter fresh waters.

*Cantharus.*—Teeth cardiform or villiform in front of the jaws, those of the outer row being compressed and lanceolate; cheeks with scales; dorsal fin with ten or eleven spines which can be received into a scaly sheath;

scales of body of moderate size; pyloric appendages few; air-bladder with two horns posteriorly. Mediterranean; from the coasts of Great Britain round the Cape of Good Hope to the Seychelle Islands.

Κάνθαρος (?).—Aristot. viii. 13.

*Cantharus.*—Ovid (Halieut. 105); Gesner de Aquatil. p. 178, pl.; Willughby, p. 309.

*Sparus cantharus.*—Lin. Gmel. p. 1274.

*Pagrus lineatus.*—Flem. Brit. Anim. p. 211.

*Cantharus vulgaris.*—Cuv. & Valenc. vi. p. 319, pl. 160.

*Cantharus griseus.*—Yarrell, i. 130.

*Cantharus lineatus.*—Thompson, Nat. H. of Ireland, iv. p. 91; Günther's Catal. i. p. 414; Day, pt. i. p. 26, pl. ix.

*Old Wife.*—Couch, i. p. 222, pl. 49.

*Geographical distribution.*—Common in the Mediterranean and along the west and south coast of England; rare in Ireland and Scotland; in the North Atlantic to Madeira and the Canary Isles.

*General habits.*—Several of the sea-breams feed on both vegetable and animal food, and the species under notice is no exception in this respect. The "Old Wife" prefers rocky ground, and is found in bays and harbours; it does not congregate in shoals; is most abundant during the summer months, retiring to deep water in the winter.

*Food of.*—The smaller kinds of seaweeds, worms, crustacea and molluscs.

*Spawning.*—Probably in the early spring months, as ova well developed have been found in this fish in February; mode of deposition of ova not known; the young of small size are seldom taken; attains the size of 16 inches or more.

*Modes of capture.*—By hooks baited with worms or mussels ; and by nets ; generally in the summer and autumn months, but also in the winter.

*Quality of flesh.*—Said to be usually soft and insipid, though it is probable that when eaten quite fresh from the sea, if the fish is at once cleaned, the "Old Wife" would prove very fair eating. I have not tasted this species, and cannot report on it, but I have found that if sea-bream are cleaned immediately and cooked the same day on which they are caught, the flesh is excellent in those kinds of which I have partaken. This fish, when taken in August and September, is said to be of moderately good taste at Boulogne and Calais, and the flesh tolerably firm.

*Commercial value.*—Seldom seen in our markets, and of no real commercial value at present. It affords, however, wholesome food to the fishermen, and its pretensions as a food fish, though not great, must not be overlooked.

*In confinement.*—They are sometimes seen in our aquariums ; and Day observes that they then constantly swim in companies.

*Names, &c.*—Although the name *Cantharus* has been given to fish of this genus, it is quite impossible to say what the *κάνθαρος* of Aristotle and Oppian was. This fish is called the Black Bream along the southern coast of England ; as the colour is subject to variation, the epithet of black is by no means a good one. It is not easy to account for the name of "Old Wife." The *κάνθαρος* and *Cantharus* of the Greeks and Latins denoted the beetle *Scarabæus* of the Egyptians ; Willughby supposed that the fish received its name from its fondness for hiding in the mud ; as the *Scarabæus* rolled its balls of mud, so this fish delighted in the same substance.

*General description.*—The height of the body is about two and a half or three to the whole length. Body compressed; dorsal spines slender and flexible, the fourth, fifth, and sixth being the highest; pectoral about as long as the head; tail forked; præorbital at its lower edge usually notched by the maxillary bone; scales ctenoid, six or seven series of scales below the eye over the cheek. Colour variable; generally bluish grey or greyish green, with darker longitudinal lines, hence the specific name of *lineata*.

### COMMON SEA-BREAM (*Pagellus centrodontus*).

GENUS *Pagellus.*—"The anterior teeth card-like without canines; the outer series generally containing larger ones than those behind; several series of rounded molar teeth in both the jaws; cheeks scaly. The spines of the dorsal (eleven to thirteen) can be received in a groove: three anal spines. Opercles not armed; scales of moderate size. Six branchiostegals. Pyloric appendages in small number; air-bladder simple. Mediterranean, Atlantic (except the shores of North America" (Günther).

*Orphus.*—Rondelet. v. 25, p. 157. Aldrov. ii. 2. p. 158.

*Sparus centrodontus.*—Jenyns' Manual, p. 356.

*Pagellus centrodontus.*—Cuv. & Val. vi. p. 180; Parn. Fish. Firth of Forth, p. 46, pl. 27; Yarrell, i. p. 123; Thompson. Nat. Hist. of Irel. iv. p. 90; Günther's Catal. i. p. 476; Day, pt. i. p. 36, pl. 13.

*Common sea-bream.*—Yarrell, *loc. cit.*; Couch, i. p. 237, pl. 55.

*Short sea-bream.*—Couch, i. p. 241; apparently a deformed specimen.

*Geographical distribution.*—Mediterranean; coasts of the Peninsula; France; Great Britain; Scandinavia.

The common sea-bream is the species most generally known, and finds its way into our markets more frequently than any other of the *Sparidæ*. Large numbers are taken during the summer months off our southern coasts. It is a bright and beautiful fish when first taken out of the water, though it is surpassed in this respect by its relative the "pandory."

*General habits.*—Frequenting the west and south coasts of England during the year, but far more abundant or more generally taken in the summer months; in severe weather it goes into deeper water. In general habits the sea-bream may be considered a solitary fish, in the opinion of the late Mr. Couch; but sometimes they assemble in large numbers towards the end of summer, and rise to the surface, when they are sometimes in Cornwall and Devonshire mistaken for pilchard shoals. As many as 20,000 and even 60,000 have been caught at one time. Being in a great measure herbivorous it resorts to the seaweeds of the rocks, where it finds abundant food both of animal and vegetable nature.

*Food.*—Seaweeds, crustacea, worms, molluscs, small fish. Mr. Dunn found the stomachs of these fish full of wheat after a vessel laden with this commodity had been wrecked. The sea-breams are greedy feeders; the stomachs and intestinal tracts in all instances I have examined have been found to be loaded with food of the mixed nature just mentioned. On this food they grow tremendously fat.

*Spawning.*—The spawn appears to be shed in January or even earlier in the winter, for young about one inch in length have been found in January in the stomachs of other fishes. The spawning would take place, therefore, in deep water, but we are ignorant, as in many other instances, as to the mode of deposition of the ova. Young fish are destitute of the black shoulder mark which generally characterises the adults; when they are from five to seven inches long, they are called "chads," and abound in immense numbers in the vicinity of seaweed-girt rocks and harbours.

*Modes of capture.*—By hooks baited with lug worms, mussels, pieces of squid, small fish, &c.; in seine-nets; in the summer and autumn months.

*Quality of flesh.*—Not generally much esteemed; but when fresh out of the water and immediately cleaned, the sea-bream is by no means a fish to be despised. Being excessively fat, they will not take the salt well, and being very greedy feeders, having their stomachs and intestines loaded with food, they will not keep at all in warm weather. Yarrell gives the following recipe for cooking sea-bream, which from experience I can recommend—"When thoroughly cleaned the fish should be wiped dry, but none of the scales should be taken off. In this state it should be broiled, turning it often, and if the skin cracks, flour it a little to keep the outer case entire. When on table the whole skin and scales turn off without difficulty; and the muscle beneath, saturated with its own natural juices which the outside covering has retained, will be found of good flavour."

*Commercial value.*—None of the sea-breams stand high in this respect. The common sea-bream is often to be seen in the London markets and elsewhere in the south and midland provinces. Numbers are taken at Brixham and Plymouth, and sell at a cheap rate; a good-sized fish will fetch 4*d.* or 5*d.* at retail price at Brixham and Plymouth; and if fresh and cooked immediately as recommended, the sea-bream is very "good meat."

*General description.*—Height of body about 3¼ in the total length; interorbital space flattened; præorbital narrower posteriorly than in front, and not notched; the pectoral fin reaches to the origin of the anal, tail fin much forked. Teeth very fine, intermixed posteriorly with small molars irregularly arranged. Colour, orange scarlet above, lighter beneath, with a large black blotch on the shoulder, which is absent in young specimens.

### SPANISH SEA-BREAM (*Pagellus bogaravio*).

*Pagellus bogaravio.*—Cuv. & Valenc. vi. p. 196; Günther's Catal. i. p. 480; Day, pt. i. p. 57, pl. xiv.

*Spanish bream.*—Couch, i. p. 255, pl. 53.

I have not met with more than two examples of this species of sea-bream. According to Couch it is the best-known species of all the family to Cornish fishermen. It seems to be confined to the coasts of Cornwall and Devonshire, and to be more common in the Mediterranean. I know nothing of it as food. It seems to be solitary in its habits; it is caught with baited hook and in seine-nets. Its local habitat, to which it is limited, precludes it from forming a fish of any importance commercially, and a further notice of it seems not to be required here. In point of flavour and edible qualities generally, the Spanish bream probably differs not from its congeners.

### THE PANDORA (*Pagellus erythrinus*).

*'Ερυθρῖνος* (?).—Aristot. x. 11.

*Erythrinus.*—Gesner, de Aquatil. 365; Willughby, p. 311, tab. v. 6.

*Sparus erythrinus.*—Lin. Syst. i. p. 469; Jenyns' Man. Brit. Vert. p. 355.

*Pagellus erythrinus.*—Cuv. & Valenc. vi. p. 170, pl. 150; Parnell, Fishes Firth of Forth, p. 43, pl. 27; Günther's Catal. i. p. 473; Day, pt. i. p. 40, pl. xvii.; Couch, i. p. 233, pl. 53. There is a confusion in Yarrell's figures and descriptions.

*Geographical distribution.*—"Mediterranean; Black Sea; coasts of the Peninsula, of France and Great Britain; Canary Isles" (Günther). The erythrinus is not so common on our coasts as the foregoing species, though I have seen many caught at Brixham in October. It is common in the Mediterranean, but its course northwards is not extensive.

*General habits.*—Like most of the family, the erythrine, or pandora, as is the name by which it is known in Cornwall and Devonshire, is a frequenter of our coasts during the summer and autumn months, retiring into deeper water in severe weather. It is rather solitary in its habits.

*Food.*—Crustacea, worms, molluscs, especially (as I have found) small pectens, small fishes, seaweed.

*Spawning.*—Nothing appears to be known as to the time of spawning or the deposition of the spawn.

*Modes of capture.*—In seine-nets, and by baited hook; also in trawl with the common species.

*Quality of flesh.*—Excellent in my opinion as well as in that of those who have had opportunities of eating the fish soon after capture. Mr. Day says it is "not esteemed in Britain;" probably because it is but little known. The fishermen and fish buyers of Devonshire and Cornwall appreciate it, and will ask a higher price for a pandora than for the common sea-bream, that is, if you wish to purchase one or two from the lot. At wholesale the pandoras are sold together with the common species. Cooked in fillets with parsley forcemeat, the flesh is firm and highly commendable; doubtless it would prove very good when baked as per recipe given above. Willughby says its flesh is best in the winter. Off Nice it appears to be found throughout the year.

*Commercial value.*—Not great, because not generally known and distinguished from the common sea-bream; but it is a fish whose acquaintance gastronomically is worth cultivating; and from an examination of the stomachs and intestines of this fish, which do not exhale the same strong odour as do those of the common kind, I should imagine it would keep somewhat longer in good condition. It does not seem to be so coarse a feeder as the other species, and prefers the cleanly pectens and other small bivalves.

*Classical allusions.*—Aristotle's *eruthrinos*, mentioned also by Ovid (Halieut. 104), Pliny (ix. 16, 23), Athenæus (vii. 58), and Oppian, may possibly be our pandora; but these authorities have left no clue, beyond the very vague one of the colour being red, whereby it is possible to identify the fish.

The usual name of this species in Devonshire and Cornwall is *pandora*, but why so called I have been unable to ascertain. The term "King of the Breams" perhaps alludes to its superiority over the rest of the family, which it certainly can claim both in quality of flesh and brilliant purple iridescent colours when fresh from its native seas.

*General description.*—The height of the body is about 3½ in the total length; interorbital space convex; jaws even; maxilla reaches to anterior edge of the orbit of the eye. Teeth cardiform anteriorly, sharp and small in both jaws; two rows of molars, sometimes three irregular rows posteriorly in each jaw; no teeth on tongue vomer and palatine bones. Dorsal fin-spines of moderate length, the third being a little the longest; pectoral very long, reaching beyond the vent; ventral not reaching the vent; tail fin deeply forked. Colour of body bright roseate pink with iridescent metallic reflections, especially on the belly; under-side white.

## THE GURNARDS (*Trigla*).

*Cottidæ.*—Body oblong or subcylindrical; eyes usually lateral, sometimes directed upwards; cleft of mouth often extending to the sides of the mouth, "sometimes of hideous aspect." Dorsal fins, two, generally distinct; spinous portion less developed than the soft; ventrals thoracic; branchiostegals from five to seven; air-bladder present or absent; pseudobranchiæ present; pyloric appendages few in number, or absent; teeth in villiform bands, usually feeble and without canines; suborbital ring articulated with the præopercle; some bones of the head armed. "Carnivorous fishes, found in all seas; a few only entering fresh water. Some inhabit exclusively the fresh waters of both the Arctic regions. All live at the bottom of the water, being bad swimmers; a few are able to raise themselves into the air."

GENUS *Trigla.*—Head nearly square, with the upper surface and sides bony; scales of the body very small; two dorsals, the first much shorter than the second. Three pectoral filaments; air-bladder well developed and muscular, often divided into two parts; pyloric appendages in moderate number; branchiostegals, seven; teeth in both the jaws and on the vomer, villiform, none on the palatine bones.

## THE RED GURNARD (*Trigla pini*).

*Trigla cuculus.*—Lin. Syst. Nat. p. 497; Cuv. & Valenc. Yarrell, i. 38; Day, pt. i. p. 58, pl. xxiii.

*Trigla pini.*—Bloch, tab. 355; Lacép. iii. p. 356; Thompson, Nat. Hist. of Irel. iv. p. 71; Günther's Catal. ii. p. 199.

*Elleck.*—Couch, ii. p. 19, pl. 64.

Seven species of gurnards occur on our coasts and all are food-fish; one or two species are rather rare and local, and will not require any lengthened notice. The principal marketable kinds are the red or cuckoo gurnard; the sapphirine, known to fishermen as tubs, the grey, and the piper.

*Geographical distribution.*—The red gurnard (*T. pini*) occurs in Scandinavia and down the west coast of Europe to the Mediterranean; it is also said to be found off the American shores of the North Atlantic, where it has received the name of *Polynemus tridigitatus* (Mitchell, Trans. Lit. & Phil. Soc. New York, i. p. 449). It is one of the commonest, if not the most common of the family on the English coast on the south and west. It also occurs in Ireland and Scotland, being common in the former country from Waterford on the south up the east coast to Londonderry. It is the species which the Brixham trawlers bring in daily to the market in such profusion as sometimes to render the fish of little marketable value.

*General habits.*—Like the rest of the family its usual haunts are near the bottom; it is a bold, voracious fish, and takes a bait with eagerness.

*Food.*—None of the gurnards whose stomachs and intestines I have examined show any partiality for any special kind of food; small fishes of various kinds, crustacea, worms, shellfish, starfish, brittle-stars (*Ophiocomæ*) and small urchins (*Echini*), and not unfrequently several small stones I have found in the stomachal larder.

*Spawning.*—Gurnards are especially interesting to the naturalist as being a genus of sea fishes which was amongst the first to reveal to observation the interesting and important fact that many of our sea fishes—perhaps nearly all—emit their spawn near the surface of the water, and not, as was generally supposed to be the rule, in aggregated masses at the bottom on rocks or sand. The well-known Professor of Christiania, G. O. Sars, some years ago—in 1864, I believe—made known the fact that the ova of the cod-fish floated at the surface and there developed. Amongst other fishes, he found that the grey gurnard (*Trigla cuculus*) emitted its ova and milt at the surface. It is probable, therefore, that all the members of this genus do the same. I myself last July, when in a trawler in the North Sea, about seventy miles from land, secured in my surface tow-net, amongst interesting marine creatures of small size, a few very small fish about half an inch in length. This was in the month of July, 1882; they at once declared their parentage by the presence of the three pectoral filaments characteristic of the genus. Couch has found the red gurnard to be full of well-matured ova in January, April, and June; and young ones about 1½ inches long have been taken in August. Probably, therefore, the usual time for the spawning is in the months of May and June. Yarrell found the characters well marked in young red gurnards not more than 1½ inches long in small pools by the end of August. They probably grow rapidly when well supplied with food; but this species does not attain to a very large size; at least not very large ones are often captured. A specimen fifteen or sixteen inches in length may be considered one of good size.

*Modes of capture.*—Chiefly in trawl-nets; a few are occasionally caught with a baited hook; they are taken at imes of the year, but principally in the autumn.

*Quality of flesh.*—Gurnards are certainly as a rule rather a dry fish; the flesh, however, is very firm and of good flavour. The usual way—and perhaps the best way—of cooking them is to stuff with forcemeat and bake in a quick oven in a pie dish covered with a few slices of fat bacon.

*Commercial value.*—Not so generally appreciated as the sapphirine, and of less value in the market, but this is owing more to the smaller size of the fish than to any difference in the quality of the flesh. All the gurnards have such large bony heads, that unless the whole fish be of some considerable size, there is not much left for eating when the head is cut off. Where red gurnards are extremely plentiful, as on the Devonshire coast, they sell for very little money: Mr. C. W. Peach informed the late Mr. Couch that at Wick the red gurnard is in such little esteem as food that the greater part are thrown away as worthless. But the Scotch are sometimes odd in their fish fancies, and will not eat eels!

*In confinement.*—The gurnards seem to thrive tolerably well, at least for a time, in our larger aquariums. Their odd, sly-like, cautious ways as they creep over the artificial rockwork, using their pectoral filaments as feet, are most amusing.

*Classical allusions.*—The ancients were acquainted with some of the gurnards; to the Greeks the gurnard was known by the name of λύρα. Very little is said of it. Aristotle (iv. 9. 3) says that the *luros* gives out a grunting sound (ὥσπερ γρυλλισμὸν ἀφιᾶσιν); Ælian (Nat. Anim. x. 11) simply quotes Aristotle; the Stagirite also speaks of a fish under the name of κόκκυξ (*l. c.*), which received its name from its uttering a sound like that of the cuckoo; and Oppian mentions κόκκυγες θοοὶ as frequenting sandy bottoms; Athenæus quotes Diocles as enumerating κόκκυγες amongst fish whose flesh is dry. It is quite probable, therefore, that gurnards were known to the Greeks under the two names of *lyros* and *coccyx*, which modern systematists have retained for two species of gurnard. The noise which gurnards make when taken out of the water is caused by the escape of gas from the air-bladder through the open pneumatic duct, and it is this peculiarity which has given them the name of "*cuckoo*" and *lyra* among the ancient Greeks, and "gurnard" or "gurnet" amongst ourselves; the English word is the same as the French, "gournard," which by the shifting of the letter r stands for "grounard," from the French *grogner* "to grunt," and that from the Latin *grunnire*. Gurnet is the common word among fishermen and fish salesman; and is used by Shakspere, (1 Henry IV. iv. 2. 13): "If I be not a soused gurnet," Sir John Falstaff exclaims, "I'm ashamed of my men," which shows that one way of cooking these fish in Elizabethan times was to marinate, *i.e.* to fry and then souse in vinegar or some acid sauce, a mode recommended by Dorion and Epicharmus in Athenæus: "Score the fish across the back, fry in oil with a seasoning of salt, chopped rue, grated cheese, and serve, soused in vinegar." A similar mode of dressing gurnard is still adopted in Italy and France. For the red or cuckoo gurnard one finds the following popular names, "crooner," "soldier," "elleck" and "latchet." The first is onomatopœic; I know not the derivation of the third name; while *latchet*, which is the name at Grimsby and the north of England for this species as distinct from other species, perhaps refers to the markings on the lateral line which is crossed by vertical folds of the skin, giving the idea of latching or intertwining.

*General description.*—Height of the body 6 in the total length; space between the eyes very concave; upper profile of the snout descends abruptly and is concave; bones of the head with stellated ridges; præorbital with short denticulations; opercle with a large sharp spine; the second dorsal spine is the longest; the pectoral reaches to above the third or fourth anal ray; scales small, those on the lateral line forming lineated plates, making it appear as if crossed by a number of vertical folds of the skin, which suggested to Bloch the idea of the aciculated spines of a pine tree, hence his name of *T. pini*—"the pine-leaved gurnard." Air-bladder with two short rounded processes and a muscle on each side. Colour, reddish rose.

## THE SAPPHIRINE GURNARD OR TUB FISH (*Trigla hirundo*).

*Corax.*—Gesner, Aquat. iv. p. 299.

*Hirundo.*—Aldrov. Pisc. ii. cap. 3, p. 133; Willughby, p. 280.

*Trigla hirundo.*—Lacép. iii. p. 353; Parn. Fish. Fr. of Firth, p. 16, pl. 20; Yarrell, i. p. 47; Cuv. &. Valenc. iv. p. 40; Thompson, Nat. Hist. Irel. iv. p. 214; Günther Catal. ii. p. 202; Day, pt. ii. p. 59, pl. xxiv.

*Sapphirine gurnard.*—Yarrell (*l. c.*).

*Tub fish.*—Couch, ii. p. 21, pl. 65.

This species attains to the largest size of any of the other species, and is on this account of more commercial value than the rest.

*Geographical distribution.*—The Mediterranean and Adriatic; Norway; the western coast of Europe, Great Britain, and Ireland. It is common on our coasts, but not so abundant as the red gurnard; more are taken on the south coast, as at Brixham and Plymouth, than on the northern coasts. I saw but few, comparatively speaking, at Grimsby and in the North Sea. It occurs in Scotland and Ireland.

*General habits.*—Like the other species this one is chiefly found near the bottom, though it occasionally rises to the surface. Mr. Day says that the young generally lie at the bottom in shallow water with their pectoral fins widely expanded, the blue colours of which, and the dark blotch covered with white spots, give them the appearance of gorgeous butterflies, as of course the inner or coloured side becomes that portion which is most exposed to view. The brilliancy of the blue colouring of the inside of the pectoral fins, as the fish expands them when swimming, is certainly a beautiful sight and one not easily forgotten.

*Food.*—Other fish ; crabs and other crustacea ; molluscs, as pectens, razor-shells and other bivalves. I have taken from the stomach three small soles, 3½ inches long, and several crabs.

*Spawning.*—Probably early in the spring—ova well matured having been found within them in December and February—and perhaps sometimes later, as Couch found the roe enlarged in May and July. The spawning probably takes place near the surface, as is known to occur in some species of the genus, and perhaps will be found to be the case in all ; but it will be necessary to investigate more fully into the whole very interesting question of the mode of deposition of the spawn of our sea fishes, before we can safely arrive at any definite conclusion ; for species closely related may present differences in habits, modes of life and development. The tubs sometimes grow to a large size ; Thompson mentions one 2 feet or more in length, and weighing 14 lb. ; Couch mentions one he had seen of the weight of 11 lb.

*Modes of capture.*—By the trawl ; occasionally by baited hooks ; sometimes in the seine-nets.

*Quality of flesh.*—Firm and well tasted, but like the gurnards generally rather dry. In the north of Europe it is salted and used as ship provision.

*Commercial value.*—This fish is more valued than the rest of the gurnards; I believe simply on account of its large size, and as affording something substantial and enough for three or four people after the loss of its head, rather than for any supposed superiority of its flesh. I have eaten of four species, and I prefer the piper (next to be described) to any of them.

*In confinement.*—The tubs seem to thrive fairly well in an aquarium, at least the smaller specimens. Lloyd remarks that when in an aquarium, any shrimps, of which fish generally are very fond, have fallen to the bottom and got under the sand, the tub fish would make use of the free rays of its pectoral fins to arouse them by feeling, hooking and poking about them.

*Names.*—This fish derives its popular name of *tub* from its thick form, which gives it a short or tub-like shape; but the root of the word *tub* is not known. It has obtained the name of sapphirine from the gem-like brilliant blue colour of the inside of the pectoral fins, which however only display their beauty when the fish is in the water. Hirundo, the specific name of this fish, was first given by Aldrovandi, why, it is not easy to see. However, it has been adopted by the French: *l'hirondelle de mer* being one of its names, *le perlon* and *rouget grondin* being others. "Crouner," "crounie," "garnet," are of course onomatopœic.

*General description.*—Head very large and more flattened than in the red gurnard, to which in general form it bears resemblance. Snout rather elongate and upper profile nearly straight; interorbital space concave; præorbital with prominent spines, first dorsal fin nearly smooth; second the longest; pectoral fin very large, reaching to the seventh or eighth anal ray. Scales small, lateral line unarmed; air-bladder tri-lobed and large, furnished with thick, strong muscles of the striped or voluntary kind. Colour brownish-red; pectoral fins brownish-red outside, blue on the inner surface. In young specimens the oval dark-blue patch is sprinkled with small whitish or light-blue spots, traces of which sometimes remain in the larger fish.

### THE GREY GURNARD (*Trigla gurnardus*, Plate IV.).

*Goccyx alter.*—Bellon, i. p. 207.

*Gornatus* s. *gurnardus griseus.*—Willughby, p. 279, tab. S. 2.

*Trigla.*—Artedi, Gen. Pisc. p. 46.

*Trigla gurnardus.*—Lin. Syst. Nat. i. p. 497; Lacép. iii. p. 358; Parn. Fish. Firth. of F. p. 18, pl. 22; Yarrell, i. p. 53; Günther, Catal. ii. p. 205; Day, pt. ii. p. 62, pl. 65.

*Gurnard.*—Couch, i. p. 27, pl. 68.

*Bloch's gurnard.*—Couch, ii. p. 29, pl. 69.

*Grey gurnard.*—Pennant, Brit. Zool. iii. p. 370, pl. 65.

The grey gurnard is the most common of all the British species.

*Geographical distribution.* — The Mediterranean and Adriatic, Baltic, west coast of Europe. An abundant species all round our coasts, extending northwards to the Orkney and Shetland islands, and occurring often in vast shoals. Common round Ireland and Scotland.

*General habits.*—Perhaps more decidedly gregarious than other gurnards. According to Couch this species is less sensible than others to the influence of heat and cold, and therefore is as common on the northern coasts as on the southern; it is very abundant in the North Sea, and the Grimsby fishermen every day bring vast quantities to the market. They associate in the fine summer weather in large numbers on the surface of the water, rising and sinking for short distances and uttering, Couch says, a short grunt, as if in self-gratification. At other times they appear as if asleep, and display no animation till an attempt is made to catch them.

*Food.*—I have found in their stomachs crustacea; crabs, as *Portunus depurator*, whole and semi-digested; small fish, as *Cottus* and shellfish; occasionally a few stones, which the fish has swallowed with its food.

*Spawning.*—As a rule in the spring; but they are thought by some to spawn twice in the year, in the months of December and January, and in those of May and June. It was in this species that Sars first discovered that spawning took place near the surface of the water; and that the eggs are developed as they float. This gurnard never grows to any size; seldom exceeding a foot in length. I have not met with any above 15 inches long. Pennant's statement that they are often found at the length of 2½ feet, seems to me to require confirmation.

*Modes of capture.*—By the trawl in large numbers; like the rest of the gurnards they are voracious fish, and will take a baited hook. Thompson says that in Ireland many are caught during the summer and autumn by hooks, baited with sand-eels, young herrings, bit of meat, or a slice of one of their own species.

*Quality of flesh.*—Rather dry, but not dissimilar in general from the rest. Owing to their small size they are not much esteemed; nevertheless I find that specimens of about a foot long are very good eating. I could not distinguish any difference in flavour between this and the red gurnard.

*Commercial value.*—Always sold at a cheap rate, unless specimens of an unusual size occur. Couch mentions that he has known them sold at 2*s.* 6*d.* the hundredweight, and 30 for a penny; the usual price being 3 or 4 for a penny. Although commercially the grey gurnard is of little comparative value, it is of considerable importance in affording a wholesome and very cheap food for the poorer classes.

*Names.*—*Croonack*, *crooner*, *gowdie*, *hardhead*, *knowd* or *nood*, are names of this fish. The two first are evidently onomatopœic, having reference to the noise produced by the fish. Hardhead would suit the rest of the gurnards as well as this species; *gowdie* is a Scotch name for the fish; *knowd* is an Irish one. The Welsh *penhaiernyn* means "iron-headed."

*General description.*—Snout rather long and profile nearly straight; space between the eyes concave; præorbital anteriorly denticulate or semi-spinate, more decidedly spinate in young specimens. Opercular spine strong, in young specimens equal in length to that of the shoulders; pectoral fin does not quite reach the commencement of the anal; second dorsal fin somewhat longer than the third; lateral line with bony plates, or spines in the young fish forming a well-marked white band. Colour dark grey, with blackish roundish blotches above, and little below the lateral line; lower parts white or whitish, clearly defined. The brownish-grey colour often with numerous small clear yellowish spots.

The fish described as *T. Blochii* by Yarrell and Couch appears to be a well marked variety of the grey gurnard, and not a distinct species; the chief external differences are the possession of a large black blotch on the dorsal fin, and the absence of white or yellowish spots on the body of the *T. Blochii*. I obtained many specimens of this variety at Brixham on a trawling expedition in the month of October last year; the smallest being about 3 inches and the largest about 7 inches in length; the dorsal blotch was in all conspicuous. As Dr. Günther says, "the identity or non-identity of these fishes can be proved only by a continued examination of them on different parts of the coast."

### THE PIPER GURNARD (*Trigla lyra*, Plate. III.).

*Lyra.*—Gesner, iv. p. 516; Willughby, p. 282.

*Cuculus.*—Salv. p. 160. f. 70; Willughby, tab. S. 2.

*Trigla.*—Artedi, Gen. p. 46, sp. 9.

*Trigla lyra.*—Lin. Syst. Nat. i. p. 469; Lacép. iii. pp. 339, 345; Thomps. Nat. H. Irel. iv. p. 74; Yarrell, i. p. 51; Günther, Catal. ii. p. 208; Day, pts. i. & ii. pp. 64, 65, pl. xxvi.

*The piper.*—Yarrell (*l.c.*); Couch, ii. p. 23, pl. 66.

In size, beauty of colouring, peculiarity of form, and in excellence of flesh, the piper is a very noticeable fish.

*Geographical distribution.*—Mediterranean; west coast of Europe, and the British seas. On the south and south-western coasts of England it occurs tolerably frequently; but it cannot be said to be a very common fish anywhere on our coasts; in the north of England it is little known, and in the north of Scotland there is no record of its capture. In Glasgow it is not so rare. Thompson records it as occurring on the south and south-west coasts of Ireland; but he says that he had only seen two Irish specimens in the town of Galway; and he thinks that some of the recorded captures of this species relate rather to the red gurnard. The Devonshire trawlers at Brixham often bring in pipers with other gurnards; but the catches are uncertain, and never occur in large quantities.

*General habits.*—These gurnards are more solitary in their mode of life than the rest, and great wanderers; now not infrequent in a certain locality, and now very rarely met with.

*Food.* — Doubtless similar in this respect to other gurnards. I find recorded in my note-book, as being found in the stomach of a piper, crabs and periwinkles. Day says the stomach of one opened was full of *Ophiuroidea*, which I have also noticed in some of the other gurnards.

*Spawning.*—Nothing definite known. It grows to the size of two feet in length, and attains the weight of 3, 4, or even, it is said, by Jenyns (Manual, p. 342), of 7 pounds. Fish of the length of 1 foot or 15 inches are more common than larger specimens.

*Mode of capture.*—By the trawl.

*Quality of flesh.* Excellent; firm and less dry in texture than the other gurnards. Quin was right when he extolled its merits. Though "he would whistle Falstaff for no man," he could pipe the praises of the piper!

*Commercial value.*—Though highly prized as excellent food, the piper is not of so great importance as the tub gurnard, by reason of its being far less common and comparatively little known.

*General description.* — Head large and high; snout with profile deeply concave, and having two broad, flat triangular plates, each with several sharp and strong spines; anterior orbital spines very strong; opercle with a long sharp spine; the coracoid spine very long, nearly half the length of the bones of the head, with rough stellated ridges; dorsal spines strong, the third being the longest, the spines which form the edges of the dorsal depression strong and sub-triangular; pectoral fin long, reaching beyond the sixth anal ray. Lateral line unarmed, straight, and not very distinct; air-bladder oval, smallest at anterior portion and pointed. Colour, rose red, becoming paler in time.

*Names.*—The *Λύρα* of the Greeks has been already mentioned; when captured the piper is said to emit a hissing or whistling sound. This is said by Aristotle of the *chalcheus* (whatever that name may designate) (*οεῖ οἶον συριγμόν*); while the *lyra* is said to grunt. The popular name of *rochet* used of this and another gurnard is from the French *rouget*, and has reference to the "red" colour. The piper is mentioned by Anstey, in his satirical poem of 'The New Bath Guide,' as a dish for an invalid:

> "But what after all is the best of the story,
> She's ordered for dinner a piper and dory."

Other species of gurnards are the *T. lineata*, and *T. obscura*, "the streaked," and the "long-finned captain." The former, which may attain the length of a foot, is said to be good; but it is rarely taken, and occurs only on the south and south-west coasts of England, being rather a Mediterranean species. The *T. obscura* is even more rare. Though for weeks examining the fish in the market at Brixham, I could only meet with a single specimen. These two species may, therefore, be passed over as having no claim to the title of commercial fishes.

### THE GREAT WEEVER (*Trachinus draco*, Plate III.).

FAMILY *Trachinidæ.*—Body elongate, naked or covered with scales; one or two dorsal fins, the spinous part being always much less developed and shorter than the soft anal or soft dorsal; ventrals thoracic or jugular;

branchiostegals 5 to 7; pseudo-branchiæ present; air-bladder usually absent; pyloric appendages few or wanting. Cleft of mouth horizontal, lateral or almost vertical. Teeth in villiform bands, small and pointed, no molars or trenchant teeth; suborbital ring does not articulate with the preopercle. Bones of the head sometimes armed. Carnivorous fishes, cosmopolitan, living at the bottom of the shores of all the seas; chiefly littoral, some entering fresh waters. Generally inactive.

GENUS *Trachinus.*—Body elongated, cylindrical; cleft of the mouth oblique; eye lateral, directed upwards. Teeth, villiform in both jaws, on the vomer, palatine and pterygoid bones, none on the tongue. Operculum and præorbital armed; preopercle serrated; opercle with a strong sharp spine. Dorsal fins two, the first with 5 or 7 spines; ventrals jugular; scales very small cycloid; air-bladder absent; branchiostegals 6; pseudo-branchiæ present; pyloric appendages few.

*Δράκων.*—Aristot. viii. 13; Ælian, ii. 50.

*Araneus.*—Pliny, ix. 48.

*Draco marinus.*—Pliny, ix. 27.

*Trachinus.*—Artedi, Gen. p. 42.

*Trachinus draco*—Lin. Sys. Nat. p. 435; Jenyns' Manual, p. 335; Yarrell, i. p. 24; Günther's Catal. ii. p. 233; Day, pt. ii. p. 79, pl. xxx.

*Greater weever.*—Couch, ii. p. 43, pl. 73.

*Geographical distribution.*—Mediterranean; western coasts of Africa; coasts of Europe. Not uncommon along the coasts of Britain, south and west; but decreasing towards the north; rare in Scotland and Ireland.

*General habits.*—Nearly always near the bottom and often buried in the sand with the head only uncovered, but occasionally taken in floating nets in deep water.

Couch says, that when thus caught it has always been in the early morning casts of the net, as if the fish thus mounted aloft only in the darkness of the night. This as well as the other British species, the lesser weever, is provided with formidable spines on the opercle and first dorsal fin, capable of inflicting great pain and causing much distress. These weapons are used with great effect and directed with precision. If any part of the body be touched, the fish bends it and throws back the head with a violent jerk. Fishermen are often "stung" by the weever, but probably more frequently by the lesser species, which is very commonly taken by shrimpers in their nets close to the margin of the sea. The part injured immediately swells, and the swelling extends to a considerable part of the leg or arm, according as the foot or the hand have been pricked. Rubbing with olive oil and opium is found to be the best remedy. Both the opercular spines which have two grooves, and those of the first dorsal are poisonous organs; these latter besides being grooved, are said to possess a cavity within the spines for the reservation of the poison, but no poison-gland has been discovered. The fluid mucus with which the spines are charged is doubtless the poison. Even after death, weevers' pricks have been known to occasion symptoms of poisoning. Fishermen seemed to me to be rather reckless in handling these fish. "Familiarity breeds contempt."

*Food.*—Crustacea, especially small shrimps; small fish. I have found in the stomach small fish, small crustacea, and the remains of chætopodous worms. Couch found in one two gobies and a launce; in another, a squid 5 inches long.

*Spawning.*—Probably in the early summer. Couch saw a young specimen three-fourths of an inch in length, which had been taken in a drift-net in the month of August, and he remarks that even at this early stage of its existence it displayed the order and degree of development of its parts. The long and sharp spine on the hinder part of the neck had not come through the skin, but as the skin became dry, the ridge formed by it could be seen. The bony structure before the eye was visible, but not prominent. Although its habits confine it to the bottom, it is probable that the weever ascends the water and emits its spawn near the surface, as some of the Pleuronectidæ, very decided ground-dwellers, are known to do. The weever attains to the length of 17 inches; but one of a foot long is about the usual size of those captured.

*Modes of capture.*—By the trawl, in sprat or seine-nets; or with baited hook attached to deep-sea lines, usually in summer and autumn.

*Quality of flesh.*—Generally esteemed, but seldom eaten except by the fishermen. These fish are said to be sometimes sold in Whitechapel as food, under the name of "Spitalfields weavers." The flesh is white and firm, and in my opinion very good. In France and Spain, it is said there are police regulations enforcing the removal of the spines before the fishermen are allowed to expose the fish for sale. They are good boiled or fried.

*Commercial value.*—Seldom seen in the markets, and at present of very little value. Nevertheless, the fish possesses value in itself as affording good and wholesome food. Having a low standard of respiration, they keep alive some time out of the water, and the flesh remains good for some days; they bear to be conveyed long distances, and are on this account esteemed in France.

*In confinement.*—Said not to show any propensity to hide themselves under the sand in the Westminster Aquarium.

*General description.*—Height of the body about 5½ in the total length; cleft of the mouth very oblique and wide; maxilla reaching a little beyond the posterior orbit; snout obtuse with two spines pointing sideways and forwards; intraorbital space narrow; two small spines on the anterior part of the orbit; suprascapular minutely serrated. Four flat and badly marked spines on the preopercle, but these are sometimes, as in the specimen before me (13 inches in length), quite absent; there is merely a waved lower margin; ventral fins close to the throat (jugular). The first dorsal has five acute strong spines, the third having the longest membrane, black; pectorals very broad; tail fin when extended, slightly sinuous; operculum with a strong and sharp spine pointing towards the tail; lateral line arising from the top of the suprascapular runs straight towards the tail; maxilla triangular, broad at the base; eyes directed upwards; scales, small cycloid; teeth villiform on both jaws, on the vomer, palatine and pterygoid bones; colour, greyish-yellow, darker along the back and above the lateral line, below which the parts are lighter and crossed diagonally with broad and distinct yellowish-brown lines; under-jaw prominent.

The lesser weever (*Trachinus vipera*), which is even more poisonous than the other, is said to be good eating. Shrimpers say they are very good. Their small size, however, excludes them from the list of commercial fishes.

*Names.*—Aristotle mentions a fish called *Δράκων* only once, and merely says that it is one of the kinds which are found near the shore. There seems no reason to doubt that it is the same fish which Ælian mentions by the same name, and which he says poisons by its prickles. Pliny speaks of a fish by the name of *draco marinus* (ix. 28), which when thrown on the sand works out a hole for itself with its nose with wonderful quickness. In another place (ix. 48), he speaks of a fish called *araneus*, "sea-spider," which is very dangerous from a sting on its back. Oppian (Halieut. ii.459) also mentions *δράκοντες* as being armed with sharp spines. The greater weever is probably denoted by all these names. The name of the genus *Trachinus*, framed by Artedi and still retained, must be from *τραχύς*, "rough," in allusion to the armed head. The English name *weever* is clearly related to "viper," the Middle-English form of which is *wivere*, "a serpent" (see Chaucer) (Troil. iii. 1012); it has nothing to do with the French *la vive* in reference to this fish being able to "live" a long time out of water. The old historic forms show that the word was *vivre*=Lat. *vipera*, just as the Greeks and Romans gave to this fish the name of *draco*. In Sussex it is called the sea-cat, cat-fish and sting-bull. The cat-fish of the North Sea is the wolf-fish (*Anarrhicas lupus*). Drayton refers to the weever in the following lines :

> "The weever, which although his prickles venom be,
> By fishers cut away, which buyers seldom see ;
> Yet for the fish he bears, 'tis not accounted bad."
> —(Polyolb. s. xxv.)

### MACKEREL (*Scomber scomber*).

FAMILY *Scombridæ*.—Body oblong or somewhat elongated, naked, or covered with scales, generally small ; gill-openings wide ; eyes lateral ; teeth variable. The infra-orbital bones do not articulate with the preopercle. Two dorsal fins, the spinous portion less developed than the soft or than the anal, the soft dorsal and the anal being

sometimes divided posteriorly into finlets. Ventrals thoracic (jugular in two genera), sometimes rudimentary or absent; branchiostegals 7 or 8; pseudobranchiæ generally present; pyloric appendages usually numerous; air-bladder present or absent.

The fishes belonging to this family are pelagic forms, that is to say, they inhabit the surface of mid-ocean. Pelagic fishes belong to various orders, but this series contains no Anacanths nor Pharyngognaths; and they differ much from one another in their mode of life. Nearly all are rapid swimmers and have great powers of endurance, able to continue their course almost, apparently, without rest for days and weeks together. Their shapes are eminently adapted for a swift passage through the water. Some pelagic fishes are able to take flying leaps out of the water (flying fishes), as in *Dactylopterus* and *Exocœtus.* Others are not good swimmers (*Hippocampus* and *Antennarius*), but float about with the seaweeds. The sucking fishes (*Echeneis*) attach themselves to ships, other fish, or floating objects. The fishes of the mackerel family are carnivorous, often of brilliant colours, and highly esteemed as food; they inhabit the high seas of nearly all the regions, and several of the species have a wide range.

GENUS *Scomber.*—Body rather elongate; cleft of the mouth wide; scales small; first dorsal with feeble spines separated from the second by an interspace; behind the second dorsal, and the anal fin which reaches to the caudal fin, are 5 or 6 finlets. Teeth small in the jaws, present or absent on the vomer and palatine bones; branchiostegals 7; pseudo-branchiæ present; air-bladder simple when present. Pyloric appendages very numerous. Fishes of this genus inhabit nearly all temperate and tropical seas of both hemispheres; but they are not known to occur on the coasts of the temperate parts of South America.

## THE MACKEREL.

*Σκόμβρος.*—Aristot. vi. 17; viii. 12, 13; ix. 2; Ælian, xiv. 1; Athenæus, iii. 121; vii. 321; Oppian, Halieut.

*Scomber.*—Ovid, Halieut. 94; Pliny, ix.; Martial, iii. ep. 2; iv. ep. 86; xiii. 1; Gesner, Aquat. p. 841; Willughby, p. 181, tab. M. 3.

*Scomber scomber* (or *Scombrus*).—Lin. Sys. i. p. 492; Cuv. & Valenc. viii. p. 6; Parnell, Fish. Fr. of Forth, p. 50; Yarrell, i. p. 137; Jenyns' Man. p. 360; Thompson, Nat. H. of Irel. iv. p. 92; Günther, Catal. ii. p. 357; Day, pt. ii. p. 83, pls. xxxii. and xxxiii.

*Mackerel, dotted and scribbled.*—Couch. ii. pp. 67, 81, pls. 79 and 81; p. 84, pl. 80, fig. 2.

*Geographical distribution.*—Widely distributed, occurring from the Mediterranean along all the coasts of Europe, crossing the Atlantic, and found on the American coasts from Greenland to Cape Cod southwards in Massachusetts. Occurring on the coasts of the British Isles, but varying in their times of appearance in different localities, which will be considered under the head of

*General habits.*—Mackerel are gregarious wanderers, approaching our shores at certain times of the year in countless thousands. Formerly it was supposed that mackerel arrived from very distant waters in the northern latitudes to our coasts, as was also once believed of the herring, that in land-locked bays off Greenland they were to be seen in multitudes with their heads buried in the l, and tails erect; that in this manner they passed the winter. It is now known that there is no truth whatever in the assertion. Mackerel pay their visits to our shores, not from northern climes, but from deep water not necessarily a great many miles distant from our coasts. In the early period of the year, January and February, they usually begin to move from the deeper parts of the Atlantic to our coasts; in May and June large shoals make their appearance to the south-west of the Scilly Islands, full of spawn, large detachments passing towards the Bristol and St. George's Channels, others taking a more northerly route towards Ireland, the largest proportion being thought to move towards the south coast of England. Besides these immense shoals of spawning fishes, there are also shoals of smaller ones, which are found off the south coast, their movements being apparently, to some extent, influenced by temperature and tidal phenomena. On the English coast mackerel appear at first in deep water, some 60 miles distant from the Land's End, as early as January, and the Cornish fishery begins generally about the end of February, and extends into June. May, June and July are the months in which most mackerel are caught by the drift-nets in the English Channel and in the North Sea; but many are caught in August and September, as well as in October and November; indeed, some are taken on some parts of our coast in every month of the year. In Ireland Kinsale has long been the head-quarters of this fishery, which is carried on from March to June and even later. In Galway and in Donegal Bay the fishery extends from June to November. Temperature, no doubt, to some extent, exercises some influence on their movements, causing them to arrive earlier in some places at particular times than is their wont. In mild seasons they are sometimes taken at Portsmouth as early as January or February; but Plymouth is supposed to be the earliest place to whose shores they resort, and where they are taken from 10 to 30 miles from the land. The principal cause of the migrations of the mackerel is without a doubt to be assigned to their search after food, and not to spawning instincts. It is known that mackerel spawn near the surface of the deep water miles away from our shores, and there would be no reason therefore for their visiting the shallower waters of the coast for that purpose. They spawn in May and June. Being surface fish they would at this time of the year find abundant supply of fattening food in the crab larvæ and small crustaceans which, as I have myself seen, swarm in the sea 60 miles from the land. Mackerel—as the stomachs which I have examined in the summer months, show—gorge themselves with small crustacea; their stomachs and whole intestinal tract are full of entomostraca, crustacea and crab larvæ, or their remains. But this source of food after a time fails them in sufficient abundance, as the crustacea disappear by being either devoured, or by sinking into deeper water. Mackerel would naturally be constrained to seek for surface food somewhere else, and as such surface food would be more abundant in some of its forms, notably in those of the fry of the herring and sprat, in the vicinity of the shores than in the remoter parts of the deep sea, it seems pretty certain that the visits of the pelagic mackerel to our coasts are mainly prompted by their search for food. It is not meant that the crustacean supply is that upon which mackerel mainly depend for food; but it is pretty certain, considering their great partiality for it (though perhaps not more than pertains to some other fishes), that where an abundant supply of such food exists the mackerel would remain in those parts until it was exhausted. In the early months of the year, as in January and February, there would be no great abundance of surface food creatures as swimming crab larvæ, and even the entomostraca would be, comparatively speaking, scarce; neither, again, would there be in the winter months so large and varied a supply of young surface fishes and ova, which mackerel consume in large proportions when they can obtain such food, as occurs in the spring and summer months, when most of our sea fishes spawn. But in the early months of winter on many parts of our coasts there are shoals of young herrings and sprats, and it appears that it is to them that the movements of the mackerel are at that time chiefly directed. Nor, again, is it meant that mackerel depend altogether on such food as can be procured by them in the vicinity of our coasts alone. Doubtless they retire sometimes, and perhaps generally in the cold weather of December, into deeper water, and from thence are able to get food in the shape of swimming crabs and other crustacea, small cuttle fishes (" squids ") and other creatures; but when the season of balmy spring and summer calls forth into active life myriads of living creatures, then the mackerel's energies are especially aroused, and it pursues with vigour such food as it loves, and fills itself with the countless millions of swimming or floating things that teem around it.

*Food.*—This subject has already been touched upon under the foregoing head. Briefly, it may be said to consist mainly of free-swimming crustacea of various kinds, whether as larvæ or as adult animals; other fishes, especially the young fry of various kinds, and young herrings and sprats; the floating ova of fishes; small cuttle fish, and doubtless other things. Mr. Dunn has recorded that mackerel prey upon small jelly-like creatures about the size of a split-pea of a dark green colour, which appear after heavy rains, and which are luminous. It would appear that these are probably some kind of small Medusæ such as *Cydippe* or *Beroe*: but as some fishes consume large quantities of algæ, something of this nature may be the substance in question. A microscopic examination would soon reveal its true nature. In young mackerel about six or eight inches long, I have taken out of the stomachs portions of squid, small atherines, bits of thread-like weed, and a bit of vegetable rind half an inch long.

*Spawning.*—In May and June, as a rule, off the British coasts; according to G. O. Sars, the ova are ejected at the surface of the water many leagues from land. "The ova of the mackerel," he says, "like those of the cod fish, present at their superior pole a drop of oil, which diminishes their specific gravity, so as to enable them to float on the surface. This drop remains during the whole period of evolution, and even after exclusion it is to be seen in the vitelline sac of the young fish. The young mackerel are recognisable by a sulphur yellow spot placed behind the eye, which is still almost destitute of pigment." Sars' observations were published in 1868; and since that time the spawning of mackerel has been observed by several witnesses; and floating ova have been seen in the Brighton Aquarium. Temperature influences the mackerel in its spawning, both as regards the season of its ejection, and the duration required for the development of the ovum. Fish in full roe have been noticed in winter. The development of the ovum into the free embryo is sometimes very rapid. In an allied genus (*Cybium*) of the mackerel family, the period between fertilisation and evolution of the embryo has been observed to be one at a high temperature of twenty or twenty-four hours only ; but when the temperature of the water was low nearly thirty-six hours were required. ("The Development of the Spanish Mackerel (*Cybium maculatum*").—Bulletin of the United States Fish Commission, 1881, pp. 135–163.)

Their growth is doubtless rapid, as is the rule in all carnivorous fish when supplied with abundant food. I have taken in the month of October, with a baited hook, a number of young mackerel from 6 to 8 inches in length, and these I imagine would be the young from ova ejected in May or June. These fish would probably leave for deeper water in the winter, and reappearing near the coasts the following June would be about 9 or 10 inches long. This seems to show that growth from the birth in May up to October has been fairly rapid ; but that during the interval between their departure and re-arrival the growth has been small ; and it is certain that this difference results from the abundance of food obtainable during the summer and autumn months, and the comparative scarcity obtainable in the deeper waters during the winter and early spring. Mackerel soon recover from the effects of spawning ; this is general in fish whose ova are not very large. Occasional instances of hermaphroditism have been recorded. The ordinary size of a mackerel is from 12 to 16 inches in length, but larger specimens are known to occur, 18 or 18½ inches having been noticed, weighing 2 lbs. 11 ozs., and 2 lbs. 8 ozs. respectively.

*Modes of capture.*—Principally by drift-nets ; by seine-nets ; by lines and hooks baited with a piece of squid, a slip of another mackerel's tail or some other bright and attractive looking substance—as a bit of white kid-glove or piece of red cloth ; the artificial spoon bait of small size; in fact, almost anything attractive in appearance. Drift-nets are "shot" in the evening, and after remaining a few hours are lifted, and towards daylight are shot again. Bright moonlight nights are not good for success; the fish, doubtless seeing the dangerous snare, avoid it. The seine-net is managed usually by men in two boats, one of which is rowed round the shoal, the net being thrown overboard; the other boat keeps the end of the net steady; a circular route is taken and the enclosed fish are hauled with the net on board. This is the kind of seine-netting in deep water away from shore. But many mackerel-nets are regular ground seines and are worked from the shore; they are about 150 fathoms long and from 9 to 10 fathoms deep. The mackerel is a bold biter at a bait, which it will follow quite up to the top of the water and close to the boat in which you are fishing. This is more especially true of the young fish. I have caught them in numbers in Brixham harbour, where the fishermen call the young ones of 6 to 8 inches long "Joeys." Mackerel fishing varies at different parts of the coast; it lasts from February to November; but the chief months are those between May and October inclusive. The presence of a shoal of mackerel is often denoted by the sea-gulls, which hover in flocks above them, ever and anon swooping down and securing their prey.

*Quality of flesh.*—The mackerel ranks high in this respect, the very large kinds being not so generally liked as those of a medium size. The flesh, however, soon deteriorates if the weather be warm; on this account vendors were permitted in 1698 to cry them through the London streets on Sundays, and the enactment has never been repealed. The flesh is rich and nutritious, but from containing a considerable proportion of fatty matter, is not so well suited to the diet of an invalid as some other kinds. Large numbers are sent from Norway every year to this country in boxes packed in ice, which, though very good, are not equal to a fish freshly taken from the water, as ice, though a preservative, detracts from the flavour. They may be boiled, fried, split and broiled, filleted, or stewed in wine sauce. The Cornish Sardine Company are now tinning the smaller specimens in oil like the pilchard. Formerly there was often much waste in these fish in hot weather, owing to the interval which elapsed between the time of capture and opportunities of sale. The steam-carriers, which now bring the fish quickly to the markets from the fishing-boats, in a great measure prevent this loss. The flesh of the mackerel varies much in quality according to the place where it is found. On the west coast of South America, where it is found in large quantities, it has a bitter taste, is of a faint colour, and is rarely eaten (United States Report, p. 517). The mackerel of the Mediterranean are said to be dry and flavourless.

*Commercial value.*—Of immense importance, perhaps second only to that of the herring as a national food. According to the Report of the Inspectors of Irish Fisheries for the season of 1881, the returns for the season by vessels fishing from Kinsale—the most important station of all—and five other stations, amounted to 130,250 boxes, realising £146,994. This, however, does not give any idea of the total number of mackerel caught, because there are several parts of the coast where a large number of vessels have been employed, whence no statistics have been obtained. Of the 130,250 boxes mentioned above, Kinsale supplied 82,347 boxes, but in the previous year the take there was 118,718 boxes, producing in the aggregate £138,202 13*s.* 6*d.*, or on an average £1 3*s.* 6*d.* per box. The boxes contain six score each, the prices of which of course vary—some being worth 12*s.*, others 46*s.* 6*d.* per box. Enormous quantities are taken off the English coasts, but I am not in possession of any statistics for the last few years. At Penzance drift-nets have frequently brought 100 tons in a single night. Mackerel-fishing appears to be but little carried on in Scotland. In the Moray Firth and in the Firth of Forth these fish often appear in immense shoals in July and August; only a few are caught, and these by hook and line. The all-absorbing Scotch herring engrosses the whole attention of the fishermen.

The following extract from the *Western Morning News* of April 1st, 1867, will give some idea of the sudden appearance of immense shoals of mackerel which sometimes takes place, and of the activity and promptitude necessary to convey them away so as to reach the consumers in a fresh condition. "The remarkable activity of the mackerel fishery at Mount's Bay has tested the powers of man and beast, as well as the railway officials to the utmost. So sudden and unexpected was the catch on Thursday that some buyers had the greatest difficulty in securing packages for the emergency. Friday's catch, though not quite so large, again called forth the strongest exertions; and on Saturday there was, if possible, greater excitement than on the two previous days. As early as eight o'clock it was considered that the catch was very great, scarcely any boats coming in with less than a thousand or twelve hundred fish; these sold at first for 15*s.* for six score, and subsequently for 12*s.* 6*d.* Later in the afternoon boats came in with several thousands, but these larger reports are not fully authenticated. By the 3.5 mail train upwards of 80 tons of fish were despatched, which would yield to the railway company for carriage alone £6 per ton, or about £500 for this train alone. A special train was subsequently despatched with more fish, which proceeded at a slower pace, and carriage by which cost only £4 per ton. The village of Newlyn was a scene of unusually busy work, boats coming in in rapid succession, with salesmen ready to note the quantities as each boat came within hailing distance, and sell the fish to the highest bidder, even while way was on the boat, and she could be turned without a moment's delay to the sands, where the packers were ready with baskets and tubs. Scores of carts and waggons were pushed on as fast as poor beasts could drag them. The size of the fish astonished the oldest fishermen. One person bought six for 1*s.*; the largest, after being gutted, weighed 2 lbs. 4 ozs. avoirdupois, and the quality was extremely good. It is estimated that the value of the catch to the fishermen during the three days could not have been less than £5000. It is to be hoped that the railway companies will use every effort to expedite the transit of these perishable yet valuable goods. Everything depends upon the certainty and rapidity with which they can reach the market. Three hundred tons of fish have left by rail since Thursday morning."

*In confinement.*—It is hardly likely that a restless pelagic fish like the mackerel will thrive in an aquarium; they are impatient of restriction and injure themselves by dashing about, and are said also to be very susceptible of atmospheric changes. A writer in the *Zoologist* (1867, p. 917) put some of these fish in an aquarium, 8 ft. by 6 ft., in June or July of one year, and in August of the following year two were yet alive. The presence of fellow captives of the same species which had been some time in the aquarium, appeared to exercise a controlling power on the new-comers, which should for some time be kept in the dark. It is probable that young fish of 6 or 7 inches in length, such as are called "Joeys" by the Devonshire fishermen, would be more contented in confinement than larger specimens. Nevertheless, as stated above, the mature fish have been known to shed their floating ova in the Aquarium at Brighton.

*Enemies.*—As a rule, in the economy of the inhabitants of the world of the sea, one fish preys upon another, that again upon a third, and so on. Mackerel being a swift fish, requires a swift animal to capture it, and perhaps porpoises may be mentioned as one of their chief enemies. They appear, however, to have a fish-enemy which makes its attacks in a very peculiar and *striking* manner, though the attacks of this enemy are not confined to mackerel. I allude to the garfish (*Belone*), greenbone or mackerel-guide, as it is sometimes called from its habit of frequently attending or preceding the mackerel in their migration coastwards. The mackerel are often caught with one or both of its eyes out in the nets of the fishermen. How has this happened? From the observations of Mr. Dunn, to whom I am much indebted for much valuable information on fish questions when I visited Mevagissey, last October, it would seem that the "enemy that hath done this" is the garfish, although the similar-looking fish the skipper (*Scomberesox*) is probably as unpleasant a foe to the mackerel. Mr. Dunn has seen the pike or pointed snipe-like mandible of the garfish sticking firmly in a mackerel's jaw. The former doubtless had made an attack at the mackerel's eye, had missed its aim and struck the jaw, in which a portion of the beak was ly imbedded. The skipper is often caught in the d-nets in great numbers. Thousands of pilchards are sometimes taken, with their eyes out, in the same net with the skippers. The Cornish fishermen have no doubt but that the loss of the mackerel's eyes is due to these fish which they call *hallijews*, the derivation of which name I know not.

For what reason do the garfish and skipper or saury seek the society of mackerel and pilchards? Possessed of minute teeth, weak jaws and a narrow œsophagus, they are able to swallow very small fish or other marine creatures only. The eye appears to be the coveted morsel, and this the peculiar shape of the rough beak and the numerous sharp teeth of both mandibles is eminently well adapted to secure. The nature of the food of *belone* and *scomberesox* has long been a question. Yarrell never found anything but mucus in the stomach of the garfish; it is known to bite at a bait, and Couch says that "nothing comes amiss to it that has the appearance of life and is not too large to be swallowed; but it cannot bite a piece out." Soft delicate substance such as a fish's eye, however, would readily yield to the extracting capabilities of that terrible beak; while the stomachs of the fish, feeding on any soft, easily digested food, would exhibit no trace of its having been swallowed, except, perhaps in the case of a swallowed eye, the presence of the crystalline lens. It would therefore be very interesting to examine the stomachs and intestines of these snipe-beaked fishes after they have been taken in the nets of the mackerel and pilchards fishermen, in search for the crystalline lens, which would, like the boiled eye of other fishes, be hardened by the digesting properties of the juices of the stomach.

Mackerel, like all other fish, are affected by the presence of parasitic animals, both epizoa and entozoa. Day mentions (pt. ii. p. 90) his having received from Mr. Dunn a specimen of a fish louse (*Rocinela danmoniensis,* Leach) taken from a mackerel, in September 1879, at Mevagissey. Dunn has noticed hundreds of these crustacean parasites upon mackerel close to the pectoral fin. "When half a mackerel is used as a bait, the lice will sometimes in a few minutes scoop out all the fish, leaving nothing but the skeleton and skin." The *Rocinela danmoniensis* is in size about 1 inch long; it is one of the *Aegidæ*, a family of parasitic Isopoda. Another crustacean, Henslow's swimming-crab (*Polybius Henslowii*), called by the Cornish fishermen "the nipper crab," sometimes destroys mackerel. This crabs occurs in several parts of the southern coast of England. This crab mounts to the surface of the deepest water in pursuit of its prey, among which are numbered the mackerel and running pollack (*Merlangus carbonarius*), "the skin of which it pierces with its sharp pincers, keeping its hold until the terrified victim becomes exhausted. So far as my observation extends, it is chiefly or only the male that pursues this actively predacious existence and that only for a time" (Couch, 'Cornish Fauna,' i. p. 71). The well-known fish-borer, the myxine or glutinous hag (*Myxine glutinosa*, Lin.), the great foe of cod-fish and other gadoids, sometimes bores into the flesh of the mackerel of the Norwegian fjords. Other parasites are known to trouble mackerel, &c., being found sometimes in great abundance in their insides, especially in the perivisceral cavity. The occurrence of internal parasitic worms in fish of all kinds is very common, and a glance at Diesing's 'Systema Helminthum' would show how numerous are these entozoic guests. Indeed it is scarcely possible to examine the inside of a fish without finding worms of some kind or other; but it is only when they occur in great multitudes that they appear to cause much damage to the fish. Sometimes, however, the mischief is most serious. Last year, on several parts of the coast, but chiefly on the southern shores, mackerel were sorely infested with little white cylindrical, thread-like worms, which not only were found among the viscera, but also within the substance of the flesh. In Devonshire and Cornwall this malady, which was called "the mackerel disease," occurred chiefly during the warm weather of July and August. On cutting into the back of a mackerel these creatures would reveal themselves, and of course as the flesh was more or less full of these horrid worms, mackerel were for some time at a discount. The worm in question doubtless belongs to the *Filaria piscium* of Rudolphi, which includes perhaps several different species, and which Diesing designates by the generic name of *Agamonema* ('Systema Helminth.' ii. p. 116). These worms occur in several fishes, infesting the abdominal cavity, the liver and the muscles. I have taken them in great numbers from the dory, the herring and the ling. Dr. Cobbold, our chief authority in these matters, tells me he received consignments of these parasites from various places last summer. Its life-history, I believe, has not been yet worked out. These worms are often coiled spirally when attached to the fish's viscera; these spiral forms being by some considered to be males—and are about half an inch in length. The species is the *Agamonema scombrorum* of Diesing.

*Classical allusions, &c.*—There seems to be no doubt that the mackerel, with the tunnies and other members of the same family, was known to Aristotle and other Greek writers under the name of Σκόμβρος, and to Pliny, Ovid, and the Roman authors under those of *scomber* and *lacertus;* of which *scomber* was the more general one employed. "The *thynni* and *scombri* copulate at the end of February, and bring forth their young at the beginning of June" (Aristot. vi. 16. 5). He then makes the erroneous statement that they produce their ova as it were in a purse (οἷον ἐν θυλάκῳ). He speaks of the migration of the scombri and alludes to their susceptibility to cold (viii. 14. 4). He speaks of them as shoal-fish (ῥυάδες); says that the fattest are found nearest to the shore.

Ælian has given us a curious account of some mackerel which were trained to act as decoys to the wild ones. The ancients were fond of taming fish, which we know are quite susceptible of being domesticated; and Ælian's story seems to be worthy of some credit, making of course allowances for exaggeration. As the passage has not been translated into English before, it may be as well if I gave Ælian's account here:

"In the Ionian Sea near Epidamnus, where the Taulantians live, there is an island called the island of Athenæ, where fishermen dwell. Here there is a lake in which shoals of mackerel, tame and accustomed to the place, are fed. The fishermen throw them in food, and there is a kind of compact between the fish and the men; the fish are free and enjoy immunity from capture, and live to be old. But the mackerel do not feed in idleness, nor are they unthankful for the nourishment they receive. For after having received from the fishermen their morning's meal, then they themselves go out fish-hunting, making as it were a return for the food they have received. They proceed out of the lake and join the wild mackerel which they hope to receive as guests, and meeting with them in a shoal or phalanx, they swim in company with them as being of the same race and nature. The wild fish do not avoid them, but associate with them; then the tame ones encircle the strangers, pressing themselves close to them; then they lead them away in great numbers, and will not suffer them to swim away;

then they wait for their feeders, and in return for having been well filled with food themselves, they become the means of feasting the fishermen, who come and capture the strangers and kill a great number. The tame ones hasten into the harbour, and hiding in their holes wait for their evening meal, which the men always supply, if they wish to keep the fish as coadjutors in the fish-hunt, and faithful friends. These things, as they say, are daily done, and in a wonderful way." (De Nat. Anim. xiv. I.)

Pliny mentions the scomber together with pelamides and tunnies, as being the first to enter the Euxine in shoals; he says that the scomber is "sulphur-coloured" when in the water, but when out of the water it resembles other fish; a statement which is difficult of explanation. These fish, though, as we have seen, not suited to the limited confines of an aquarium, appear to have thrived in the large salt-water preserves in the vicinity of the sea-shore, which the ancients took so much interest in. "The salt-water preserves (*cetariæ*) of Spain," adds Pliny, "are full of huge scombri." The flesh of the mackerel was not prized at all by the Greeks and Romans, who regarded it as dry and insipid, fit only for being salted (*ἐπιτήδειοι εἰς ταριχεῖαν*, as some one says in Athenæus). However, the mackerel was considered the best fish from which to make the celebrated fish-sauce of ancient times, the *garum*, so expensive and so highly prized. The garum was first of all made from a fish which the Greeks called *garos*, but it has not been identified. In the time of Pliny the best kind was that prepared from the entrails of mackerel, at the fisheries of Carthage, Spartaria (Carthagena), on the south-east coast of Spain. Here, near the entrance of the harbour was the little island of *Scombraria*, "Mackerel Island;" and here the famous pickle was made. It was known as the "garum of the allies," "garum sociorum," of which Martial speaks:

> "Exspirantis adhuc scombri de sanguine primo
> Accipe fastosum, munera cara, garum."—Ep. xiii. 102.

"For a couple of congii," Pliny complains, "we have to pay but little less than a thousand sesterces. Indeed, if we except the unguents, there is hardly any liquid that of late has sold at higher prices; nations which produce it have become quite ennobled thereby." The price of a thousand sesterces for two congii of mackerel garum may be represented by £8 17*s.* for six quarts, which would allow an enormous profit doubtless, though the ancient recipe of making garum sauce has not been preserved to us, and we are ignorant of the price of the necessary ingredients. Our English word "mackerel" is derived from the Latin *macula* "a spot," from the dark marks on the fish's body.

*General description.*—The height of the body is 5¼ to 6¼ in the total length; the length of the head about 4⅓; jaws nearly equal in length; the maxilla, covered by the suborbital, reaches to beneath the middle of the orbit, first dorsal fin having the second and third weak spine the longest, second dorsal similar to the anal; pectoral hardly equal to half the length of the head; ventral shorter than pectoral; an anal spine between the vent and the commencement of the anal fin. Tail-fin much forked, scales very small; lateral line nearly straight. Air-bladder absent. Colour greenish-blue on the back, with a number of dark transverse stripes (30 or more), more or less varying; sides and abdomen radiant with iridescent hues of gold, silver and purple. The dotted mackerel (*S. punctatus*) and the scribbled mackerel (*S. scriptus,*) described and figured by ich, are generally regarded as mere varieties. Neither of them has an air-bladder. According to Mr. Dunn, these spotted and scribbled mackerel seldom appear in the winter and spring, but come with the summer shoals.

### THE SPANISH MACKEREL (*Scomber colias*).

This is probably a distinct species of mackerel, but it occurs in no great numbers off the British coasts. A few hundred are occasionally seen in the Cornwall waters, but they are probably stragglers from more southern climes. This mackerel has an air-bladder. The flesh is said to be inferior to that of the common species. The scales of the pectoral region are much larger than the rest. The back is marked with irregular reticulated dark lines, the sides with greyish spots. As it cannot lay claim to any importance in a commercial point of view, further remarks on this fish are not thought necessary.

### FAMILY *Carangidæ*.

Body oblong or elevated, more or less compressed; eyes lateral; no articulation of the infraorbital with the præ-operculum; dentition varied—teeth, when present, conical; scales small or absent; the spinous dorsal either continuous with or separated from the soft dorsal, and less developed than it, and sometimes rudimentary. Ventrals thoracic, sometimes wanting or rudimentary. Gill-opening wide; air-bladder present; lateral line partially or entirely armed with shield-like plates. Branchiostegals usually 7, pseudobranchiæ generally present; pyloric appendages generally numerous. Inhabitants of tropical and temperate seas of both hemispheres, many species having a wide range. Carnivorous.

GENUS *Caranx* (including *Trachurus*).—" Body more or less compressed, sometimes sub-cylindrical; cleft of the mouth of moderate width; the first dorsal fin continuous, with about eight feeble spines, sometimes rudimentary; the soft dorsal and anal are succeeded by finlets in a few species. Two anal spines somewhat remote from the fin; scales very small. Lateral line with an anterior curve, and a posterior straight portion either entirely or posteriorly only covered with large plate-like scales, several of which are generally keeled, the keel ending in a spine; dentition feeble; air-bladder forked" (Günther).

### THE SCAD OR HORSE-MACKEREL (*Caranx trachurus*).

Τραχούρος.—Athen. vii. 129; Ælian, xiii. 27; Oppian, Hal. i. 99.

*Trachurus.*—Aldrov. ii. c. 52; Willughby, p. 290. tab. S. 22.

*Scomber.*—Artedi, Gen. Pisc. p. 31.

*Scomber trachurus.*—Lin. Syst. Nat. i. p. 494.

*Caranx trachurus.*—Lacép. iii. p. 63; Parnell, Fish. F. of Forth, p. 57; Yarrell, i. p. 175; Thompson, Nat. Hist. Irel. iv. p. 95; Jenyns' Man. p. 366; Day, p. ii. p. 124. pl. xiv.

*Trachurus trachurus.*—Günther's Catal. ii. p. 419.

*The Horse-Mackerel or Scad.*

*Geographical distribution.*—Coasts of Europe and Africa; East Indian and Australian seas; temperate parts of the Pacific; a common fish in the Mediterranean, and found all round the British coasts, but not generally common except off the coasts of Cornwall and Devonshire. In Scotland the scad is not at all common, and in Ireland it is taken around the coast, more plentifully on the southern and western shores than on the northern or north-eastern.

*General habits.*—The scad is not usually seen off our coasts before the beginning of April, and is doubtless in deep water during the winter months and the early springtime; during the rest of the year it is at times caught in great numbers, chiefly on the warmer parts of the coast. Owing to its susceptibility to cold, there is much variation in its appearance in the different parts of the British Isles. Full-grown fish are more solitary in their habits than the young. They have been known to run up on shore in considerable numbers, whether in pursuit of other fish, or to avoid being themselves made a prey by porpoises or by more powerful fish, one cannot say. So intent are they in pursuit of young fry, on which they feed, that they even allow themselves to be captured in landing-nets. In the cold weather they feed near the bottom of the water, but as summer advances they are surface swimmers, and seek their prey where in the warm weather it is so abundant—near the surface of the water.

*Food.*—The food of the scad consists of the young of various fishes, and of fishes smaller and weaker than themselves, which they capture in the warm weather near the surface. The sand launces are a favourite food. Worms, crabs, and mollusca during the winter and early spring months form their food. In this respect they resemble the mackerel.

*Spawning.*—In June, July and beginning of August. Young ones 3 or 4 inches long are taken in the Cornwall bays in August and September, together with young mackerel of the same size; others again not more than 2 inches long have been taken in October; and others in the same month have been taken 7 or 8 inches in length, while even in January and February young scad not more than 1 inch long have been taken from the stomachs of other fishes. From this it appears that there is considerable difference in the time of spawning. The ova are probably shed at the surface during the warm weather of summer and autumn. The usual adult size of the scad is about 12 inches in length; but it attains the length of 20 inches or more.

*Modes of capture.*—In the seine-nets set by the Cornish fishermen for pilchards; ten and twenty thousand have been caught at a time. Couch states that on one occasion men, women and children rushed into the sea and grasped the fish with their hands, amidst the shouts of assembled spectators. In the Firth of Forth they are sometimes caught in the salmon nets.

*Quality of flesh.*—Not much esteemed; in Cornwall and the Scilly Islands scad are salted, also in Ireland, so as to provide food when other fish fail from tempestuous weather. The inferiority of the flesh to that of the mackerel is inferred from the fish's name of horse-mackerel.

*Commercial value.*—Very little indeed in the markets, but in times of scarcity of other fish even the horse-mackerel may be allowed to pass muster as cheap food for the poor.

*Names.*—The ancients have left nothing worthy of record with respect to this fish, if indeed the scad be their *trachurus* or "rough-tail." Ælian (xiii. 27), mentioning probably a folk-lore story current in his day, says that if the tail of a *trachurus* be cut off, and the fish returned again to the sea, the amputated part, affixed to a pregnant mare, will certainly produce abortion. The name horse-mackerel is the more general one for this fish; scad, however, is the older word and is of Cornish origin, but its meaning is not clear. Horse-mackerel denotes an inferior kind of mackerel; the prefix "horse" in this sense being common in the English language. It has also been called "bastard mackerel." *Trachurus*, "rough tail," of course alludes to the rough armature of the lateral line. Buck-mackerel is a name of this fish in Banff.

*General description.*—Height of body, about 5 in the total length; the lower jaw the longer; maxilla reaches not quite to a level with the middle of the eye. Teeth small in the jaws, palatines, and on the middle of the tongue. Spines of the first dorsal, weak; the third and fourth being the longest, a short space between the first and second dorsal, which latter is similar to the anal. Pectoral rather long and equal to the length of the head; ventral not reaching to the vent; tail fin deeply forked; scales small, present on cheeks, opercles top of the head and body. Rondelet and Bellon describe this fish as without scales; an error corrected by Willughby, who has a good figure and description. Lateral line distinctly crossed by large plates, deeper than wide, not so distinct in large specimens; the lateral line runs straight from the head to the commencement of the second dorsal when it turns downwards, and then runs straight on to the tail; here the plates are sharp and keeled, which suggested the name of trachurus to the Greeks. Colour above the lateral line dark bluish, below that line silvery, glossed with purple and gold. A dark patch on the opercle. A beautiful variety has been described by Edwards, of a fine golden colour striped and variegated with bright blue lines having the fins of the finest carmine.

## FAMILY *Cyttidæ.*

Body elevated and compressed; gill-openings wide; eyes lateral. No articulation of the infraorbital bones with the preopercle. Teeth small in the jaws and vomer; present on or absent from the palatine bones. Dorsal fins two, close together—the first spinous; ventrals thoracic. Scales small or with bony tubercles; pyloric appendages numerous.

GENUS *Zeus.*—Body elevated and very much compressed; cleft of the mouth wide; mouth very protractile. Teeth small in the jaws and on the vomer, absent from the palatine bones; two dorsal fins contiguous, the first with nine or ten spines and its base about equal to that of the second dorsal; a series of bony plates along the bases of the dorsal and anal fins, often armed with spines; another similar series on the abdomen; scales small or absent; air-bladder large, branchiostegals seven; pseudo-branchiæ present; pyloric appendages numerous. Mediterranean; from Scandinavia to the British Isles; eastern coasts of the Atlantic; the Japanese and Australian Seas.

### THE DORY, DOREE, OR JOHN DORY (*Zeus faber*).

*Zeus s. faber.*—Pliny, ix. 18; xxxii. 11.

*Faber.*—Ovid, Hal. 110; Colum. viii. 16; Aldrov. i. c. 25, p. 112.

*Faber sive Gallus marinus.*—Gesner, de Aquatil. p. 369; Willughby, p. 294. Tab. s. 16.

*Zeus.*—Artedi, Gen. Pisc. p. 50.

*Doree.*—Pennant, Brit. Zool. iii. p. 296, pl. 41; Couch, ii. p. 118, pl. 89.

*Zeus faber.*—Lin. Syst. i. p. 454; Lacép. iv. p. 577; Yarrell, i. p. 183; Parnell, F. Fr. Forth, p. 60; Cuv. & Valenc. x. p. 6; Günther, Catal. ii. p. 393; Day, pt. ii. p. 138, pl. xlviii.

*Geographical distribution.*—The dory is common in the Mediterranean, and the south coasts of Europe and on the west and south parts of the English coasts; it becomes rare towards the north. In Ireland it occurs, but in no great numbers, all round the coast. In Scotland it is said to be not uncommon as a summer visitor on the Banffshire coast, where it is chiefly taken in the salmon nets; in the Firth of Forth it is rarely seen. A variety is met with in Japan and Australia.

*General habits.*—Its ordinary motions are said to be slow; while swimming it is usually seen somewhat on one side; and whilst resting in this position on a rock it can descry its food whether above or beneath. The form of the dory is not such as to render it an expert swimmer; it is said to float along at times with the tide; when moving food, however, is within view, it can show considerable activity, join in a quick jerky chase and with its protruscle mouth secure its fleeing prey. Couch mentions that in the opinions of some fishermen the dory employs its long filamentous dorsal appendages as a decoy, similar to what takes place in the angler or frog-fish (*Lophius piscatorius*); making a depression in the sand or hiding in rough ground it waves its fishing lines, or suffers them to float about like worms, and meditates a successful result from this artifice in the shape of some misguided victim. This supposed habit, however, requires confirmation. It probably retires into deep water during severe weather; and, although more individually are taken during the summer and autumn months, some are caught in the winter. The dory—flat and hungry-looking fish as it is—is voracious, and even occasionally so gluttonous that it has been taken with the hand, quite unable to escape.

*Food of.*—Young fish, as pilchards, herrings, flounders, and chads; crabs, molluscs, squids. From the stomach of a dory about one pound in weight, eighteen sprats, two land-smelts, and one cuttle-fish, besides a number of smaller ones partially digested have been taken. So eager is this fish after its food that it sometimes swallows small stones, together with its prey. I have occasionally found internal worms (*Agamonema*) in the liver, &c.

*Spawning.*—The spawning time of the dory is not definitely known; but it has been stated that the young are two to three inches long in August, and hence one would suggest April or May to be the spawning months. The dory has been known to attain a weight of eighteen pounds, and a size measuring twenty-two inches in length.

*Modes of capture.*—By the trawl, and in seines, chiefly through the summer and autumn; but some are taken all through the year. Sometimes caught with a spinning bait; a chad or young sea-bream is said to be an excellent lure.

*Quality of flesh.*—Very good and highly appreciated by all fish-eaters; in the delicacy and firmness of the flesh it is not unlike turbot. It is in the best condition for the table from September to the following February. South-coast dories are preferred by the fish-buyers. It is thought that the flesh is better after the fish has been kept a day or two. They are generally cooked similarly to a turbot, boiled, and served with shrimp or lobster sauce.

*Commercial value.*—Always fetches a good price in the market: it is principally bought by the wealthier classes; the greater number from Brixham and the south coast find their way to London.

*Classical allusions and names.*—The dory, common in the Mediterranean, was no doubt known to the ancients; to the Greeks there is some reason to believe that it was known by the name of χαλκεύς, to the Romans by that of *Zëus* and *Faber*. Hence modern naturalists have given it the name of *Zeus faber*. But as Cuvier said, there is no *proof* that these names stood for the dory. It seems strange that a fish of so curious a shape did not suggest something more definite and explanatory than the Greek word which denotes a "brasier" or "copper-smith," or the Latin *faber* with the same signification, or in their short notices of the fish that they should have omitted to name anything that would have served as a clue to its identity.

"The zeus, also called the faber," says Pliny (ix. 18), "is highly esteemed at Gades. Columella (viii. 16) mentions this fish as being among the most esteemed of the same place, and states that ancient custom calls the *faber* by the name of zeus. This latter word is usually associated with the great Jupiter (Ζεύς), but the word has probably nothing whatever to do with the god. Instead of the word *zeum*, some MSS. in Columella (*loc. cit*) read *zæum*, which is evidently the Latin form of the Greek word Ζαιο, which Hesychius interprets as εἶδος ἰχθύος "a kind of fish," whatever might be the origin of the Greek word Ζαιός. According to Athenæus the χαλκεύς (different from the χαλκίς) is mentioned by Heradides in his cookery book, and by Euthydemus, in his book on cured fish, who says that the *chalceus* is round. However the dory is not improbably meant by these names, and Willughby appears to me to have given the true explanation, that *chalceus* has reference to the bronzy or brass-colour of the fish, and that this name suggested to the Latins that of faber "a worker in brass." Similarly the French and ourselves after them, have called this fish the *doree*, i.e., "the golden or yellow fish," from the feminine participle *dorée* of the verb *dorer* "to gild." The fuller form of John Dory is often fancifully and erroneously referred to the Italian *janitore*, the name still given to this fish by the fishermen of the

Adriatic, in allusion to its being supposed to be the fish of St. Peter, who kept the keys and was door-keeper. Others have explained the full name John Dory by the French words, *jaune dorée* "golden yellow;" but as Professor Skeat has remarked, there is no reason why Englishmen should have prefixed this French epithet, nor why Frenchmen should cite such a tautological expression as *jaune dorée*, John is doubtless a sailor's or fisherman's expletive, like jack-ass. In old books the fish is simply the *doree* or *dorray*, the expletive of John being a later edition.

The dory is associated in dramatic literature with the name of John Quin, the celebrated actor; and some persons have supposed that the addition of "John" was given to this fish from Quin's partiality to it. The following story given by Yarrell, from Colonel Montague's MS., may be introduced here.

"An ancestor of ours, a Mr. Hedges, was an intimate friend of Quin's, and was induced by him to take a journey from Bath to Plymouth, on purpose to eat John Dory in the highest perfection, not only from procuring it fresh, but with the additional advantage of having it boiled in sea water, a matter of very great importance to the palate of Quin.

"As this journey was purposely taken to feast on fish, their stay at Plymouth was not intended to exceed a week, by which time they expected to have their skins full of doree; but that no opportunity might be lost, Quin left strict charge with the host at Ivybridge to procure some of the finest doree he could get for his dinner on his return, fixing the day.

"Whether our celebrated epicure was disappointed in his expectations at Plymouth, is not recollected; but that he might have the fish provided at Ivybridge in the highest perfection, and remarking that the place was too remote from the coast to obtain sea-water for dressing the dorees anticipated, he ordered a cask of sea-water to be tied behind his carriage. Unfortunately, the weather had been stormy, and no fish of note could be procured. Every apology was made by the host, who assured him that an excellent dinner was provided, which he had no doubt would be to his taste, but no fish. The disappointment, however, was too great to be borne with patience: after having made a water-cart of his carriage, and the appetite having been set for John Dory boiled in sea-water, no excuse, no apology would satisfy Quin, and he declared he would not eat in his house, but like a ship in distress threw his water cask overboard, and pursued his journey not a little sulky, till some fortunate stroke of wit or some palatable viand roused him to good humour. Being asked, on his return to Bath, if he did not think Devonshire a sweet country: 'Sir,' said Quin, 'I found nothing sweet in Devonshire but the vinegar.'"

*General description.*—Body oval and much compressed; head very large, as high as long; mouth protractile, cleft oblique; maxilla nearly vertical when closed; lower jaw the longer; opercles spineless. First dorsal almost continuous with the soft second portion and spinous; the interspinous membrane is prolonged into filaments of varying lengths; at the base of each spine there is an outwardly projecting spinous filament. Pectoral short, ventral long. First portion of anal fin spinous; tail-fin rounded; scales not imbricate, a few along the cheeks; lateral line descending in a curve; colour olive grey, often with a decided yellowish tinge and wavy bands. A round black spot on the middle of the side surrounded by a narrow yellow ring.

## FAMILY *Blenniidæ.*

Body elongate, more or less cylindrical, covered with scales which are generally small or naked. No articulation of the infraorbital with the preopercle. Dorsal fins one, two, or three, occupying nearly the whole length of the body; ventrals usually jugular, sometimes rudimentary or absent; anal fin long; caudal fin either continuous with or distinct from the vertical fins. Teeth fixed in the jaws or merely implanted in the gums; a posterior canine sometimes present; in some genera there are molars. Air-bladder and pyloric appendages usually absent; pseudobranchiæ mostly present. "Carnivorous fishes, living at the bottom of the shores of all regions; several inhabiting fresh waters."

GENUS *Anarrhicas.*—Body elongate, head large, snout blunt; cleft of the mouth wide; gill openings wide; strong conical teeth in the jaws, those on the sides with pointed tubercles; a double band of molars on the palate. Dorsal fin long, with flexible spines separated from the caudal, as is also the ventral; ventrals none; scales rudimentary; no air-bladder nor pyloric appendages; branchiostegals seven. "Northern parts of the temperate seas of the northern hemisphere."

### THE WOLF-FISH, CAT-FISH (*Anarrhicas lupus*).

*Anarrhicas.*—Gesner, Nom. Aq. Anim. p. 116, and Paralip. p. 4; Artedi, Gen. Pisc. p. 23.

*Lupus marinus.*—Willughby, p. 130, tab. H. 3, I.

*Anarrhicas lupus.*—Lin. Syst. i. p. 430; Jenyns' Manual, Fleming, Brit. An. p. 208; Cuv. & Valenc. xi.

p. 473, pl. 341 ; Yarrell, i. p. 277 ; Günther, Catal. iii. p. 208 ; Day, pt. iii. p. 194, pl. lviii.

Wolf-fish.—Couch, iii. p. 242, pl. 117.

*Geographical distribution.*—The wolf-fish inhabits the cold regions of the north, from Iceland and Greenland to Norway and Sweden ; it is found on the shores of Scotland and Ireland, and on the north coasts of England, but is very rare on the south of the British Islands. It is common in the North Sea, and the Grimsby fishermen bring it daily, during the summer and autumn, to the market. In the Orkneys and Shetlands it is often taken, sometimes being thrown ashore after storms. It is found at Banff, Aberdeen, St. Andrews, Firth of Forth ; it is not common off the Irish coast, and is frequent along the Yorkshire coast ; has been found at Yarmouth and the East Norfolk coast. Stray specimens now and then find their way to Plymouth Sound, and to the Cornish coast.

*General habits.*—A very bold and ferocious fish, well deserving of its name of wolf-fish. It approaches our coasts in May, and swims with a lateral undulative motion not unlike that of an eel, to which the elongated form of its body bears some resemblance. The fishermen of the North Sea give it a very bad character in point of its ferocity even when out of the water. One has been known to fasten its teeth into a mop-handle so firmly that it was swung overboard without relaxing its hold ; when shaken off, some of the teeth were left in the wood. In the Moray Firth it is said to be most common in March ; it is tenacious of life, like many of the *Blenniidæ*, and will live for some time out of the water.

*Food of.*—The strong crushing molars of the wolf-fish bespeak the nature of its food ; the hard-shelled crustacea, molluscs that live in almost impregnable houses, such as

*Buccinum* and *Nassa*, star-fishes, echinoderms, etc., are found in the stomach. Being a swift swimmer, the wolf-fish would be able to deal destructive havoc among other fishes. The fishermen even assert that it will not refuse to prey upon the dead bodies of the drowned. Its main food, however, consists of molluscs and crustacea.

*Spawning.*—Accurate information is needed with respect to the time and mode of spawning of the wolf-fish. April, May and June are probably the spawning time; it is said to deposit its ova upon the leaves of marine plants, and that the fry are of a greenish colour resembling the sea-wrack (*Zostera marina*), among which they take shelter from their enemies some time after birth. This fish attains to the length of six feet or more.

*Modes of capture.*—By the trawl; in deep seine-nets; on lines set for haddock and cod.

*Quality of flesh.*—The hideous and ferocious aspect of this fish are against its being much used as food; moreover, the smell of one after having been skinned is unpleasant. This odour entirely disappears on being cooked, as I can myself testify. Those who have eaten of it generally report well of its flavour. Lowe and Donovan speak well of it; the former says "it is excellent;" the latter considered its flesh superior to that of the mackerel, and he called it "delicious." De Kay thought the flesh when smoked somewhat resembled salmon. The late Frank Buckland reports that "it is very good." He compares the flesh to that of veal. My own verdict is, that it is good, nutritious food; cut into fillets, cooked after the manner of stewed eels, I should think it would prove equally delicious.

*Commercial value.*—The wolf-fish is not in much request, though of course it is always disposed of. The principal market is at Grimsby, to which port the North Sea trawlers bring some almost every day, from June to September. They are prepared before sent away, as follows: The fish is suspended from a beam by its head, a hook being run through the lips; it is then gutted and skinned; a sharp blow with the knife severs the tail; another decapitates it; the middle white oily-looking portion is the edible part. The wholesale price is generally from 6*s.* to 12*s.* per score, according to the size of the fish. I bought one about three feet long for sixpence, and, as I have stated, thought it very good eating. In the northern counties it is salted, while the skin makes durable bags and pockets.

*Names.*—*Wolf-fish*, from its ravenous character; *Cat-fish*, or *sea-cat*, from the round cat-like head. In the Orkneys it is called swine-fish, from a "sort of muscular motion of its nostrils, which the fishermen say resembles that in the nose of a swine." It is the *Zee-wolf* of the Dutch, and *L'Anarrhique loup* of the French. The term *wuff*, or *wauf*, used sometimes on the Yorkshire coast, is merely a corruption of the word *wolf*. The name of the genus *Anarrhicas* was first given by Gesner, from the Greek *ἀναρριχάομαι* "to climb up with the hands and feet," because the fishermen on the shores of the Baltic thought that this fish climbed up to the rocks. I have heard the name of *wolf-eel* used to designate this creature. The German *stein bider*, "stone-biter," denotes the strength of the fish's teeth and jaws.

*General description.*—Length of head, $4\frac{1}{4}$ to 5 in the total length; body elongated and compressed; cheeks swollen; profile of head very steep; snout short, cleft of mouth oblique, masseter or chewing muscles very strong; teeth unlike those of any other British fish (see characters in the *Genus*); scales not imbricated and concealed by the mucus of the body; mucus pores on the head numerous; colour grey or greyish brown, with a series of dark bands which pass vertically down the sides; these stripes vary somewhat in different individuals, being sometimes very distinct, at other times faint. From these stripes the fish has received the specific name of *pantherinus* or *leopardus*. There are many small dark brown points upon the body.

### FAMILY *Mugilidæ*.

Body, oblong and compressed; depth of the mouth, narrow or of moderate width; eyes lateral; gill openings wide; gills, four; teeth, feeble or absent; dorsal fins, two; the first with four stiff spines, separated from the second dorsal by an interspace; anal fin somewhat longer than the opposite dorsal; ventral fin with one spine and five rays, abdominal suspended from a long shoulder bone; scales cycloid, of moderate size. Lateral line, absent; air-bladder, large. Branchiostegals, from six to seven; pseudo-branchiæ present; pyloric appendages generally few. The coasts and fresh waters of temperate and tropical countries; feeding on soft matter or minute animals.

GENUS *Mugil*.—Mouth transverse, with short lateral cleft; teeth, rudimentary or absent; anterior edge of the mandible sharp, and sometimes ciliated. Upper part of the stomach very muscular; intestinal tract long.

"Migratory fishes of all the temperate and tropical regions, passing a part of the year in the sea; feeding on organic substances which are mixed with the mud or sand." (Günther.)

### THE GREY MULLETS (*Mugil capito and M. chelo*).

There is difference of opinion respecting the mullets of our coasts; Dr. Günther enumerates four kinds which he regards as distinct species. Other writers, as Yarrell and Day, retain only two, considering that some of the fish which Dr. Günther claims as true species are merely varieties. For all practical purposes it will be sufficient to confine ourselves to the "Thick-lipped" mullet (*Mugil chelo*) and the "Thin-lipped species" (*M. capito*).

### *Mugil chelo.*

*Chelon.*—Gesner de Aquatil. iv. p. 552.

*Mugil cephalus.*—Donovan, Brit. Fish. i. pl. xv.; Fleming, Brit. Anim. p. 217.

*Mugil chelo.*—Cuv. and Valenc. xi. p. 50, pl. 39; Yarrell, i. p. 241; Parnell, F. Firth of F. p. 68, pl. xxviii.; Day, pt. iii. p. 232, pl. 67.

*Mugil semptentrionalis;* Günther, Catal. iii. p. 455; Study of Fishes, p. 504, fig. 105 p. 254.

*Lesser Grey Mullet.*—Couch, iii. p. 15, pl. 123.

*Geographical distribution.*—This mullet is found in the Mediterranean, the North Sea and the Atlantic coast of Europe to Madeira, and on the coasts of Scandinavia. It is more common on the south and south-west coasts of England, but it is found all around our coasts; it is pretty common on the Devonshire and Cornish coasts in the autumn; it is well known on the eastern and western shores of Scotland, and according to Parnell a great number are sometimes taken off Dunbar; this seems to be the grey mullet of our Scottish coasts, the other species being not met with, or very rarely. It is found on the south coasts of Ireland, and either this or the thin-lipped species frequents the east coast of Ireland.

*General habits.*—The grey mullets are shore-lovers, seldom resorting to deep water; they frequent harbours, the mouths of rivers, and frequently ascend the rivers to places beyond the reach of the tide. Being dependent in a great measure on such food, whether animal or vegetable, as is found on the mud or ooze, it frequents such places, swallowing organic substances, which it is able from the conformation of its sieve-like gill-rakers to separate from the mud or sand which contains them. Mullets are eminently gregarious; they are known to associate in large masses during very cold weather, thickly lying one on the other fifty or one hundred together upon the rocks; this condition is called scale-bound, by the Devonshire fishermen. Both species are very sly and cunning fish. Mr. Dunn of Mevagissey says they are the most wary and clever fish he is acquainted with; and they appear to exhibit peculiar feelings of attachment to their own comrades when in difficulty. A shoal once entered the harbour at Mevagissey; the entrance, which is narrow, was at once barred by nets; the mullet, observing the danger, immediately tried to jump over the net. This mode of escape having been prevented by raising the net, the fish swam round and round in hopes of finding egress. They next essayed the foot-rope; one made a rush, but became meshed close to the foot-rope; a comrade observing this, came and laid itself down beside his netted comrade, and nothing could drive it away. These two were captured; the rest escaped. Dr. Thompson, the late well-known Natural Historian of Ireland, has given many interesting particulars concerning the grey mullets. He thus speaks of their playful habits near the surface of the water. "In the bright sunny days of summer, which they evidently much enjoy, a whole shoal of mullet occasionally show their dorsal above the surface of the water, and, when there are neither nets nor other cts to obstruct them, may in playfulness be seen springing a few feet into the air. This generally occurs at high water, when they appear to be more intent on roving about than feeding, and penetrate as far up the river as the tidal wave will bear them; at such times they have frequently been captured in May's dock within the town of Belfast." He adds that they are chiefly found in the most oozy parts of the Bay, and where the grass-wrack (*Zostera marina*) is abundant, and that in search of food they make considerable excavations which the fishers distinguish by the name of mullet-holes. Pennant says they "keep rooting like hogs in the sand or mud, leaving their traces in the form of large round holes." (See Thompson, Nat. H. of Ireland, iv. p. 100; and Pennant, Brit. Zool. iii. p. 437.)

*Food of.*—The food of grey mullets consists chiefly of minute objects animal or vegetal, living or dead, which they devour with portions of the mud or ooze in which such food is enveloped. The great part of the mud or sand received into the mouth is rejected, having been filtered mechanically by means of the construction of the pharyngeal apparatus. Each branchial arch has on each side down its whole length a series of gill-rakers which fits closely into the corresponding series on the adjoining arch. The whole constitutes a beautifully adapted piece of mechanism by which the larger portions of the mud, taken into the mouth, are separated from the organic food and rejected; the latter being swallowed. I am convinced, from the examination of a great number of fishes' stomachs and intestines, that a considerable percentage of *fine mud or ooze* passes into the stomachs of mullets and some other fishes; and that this fine ooze, containing almost infinitesimally minute portions of decomposed or semi-decomposed organic matter, plays a very important part as nutritious food, in some cases, perhaps, as important a part as the actual living prey which fishes swallow. The stomach of the grey mullet is peculiar. It is well described by Day: "In these fishes the œsophagus passes into the cardiac portion of the stomach which forms a blind sac; while the pyloric portion is conical externally, somewhat resembling a bird's gizzard, but which, when cut into, is found to consist of thick muscular walls formed of circular fibres, leaving a small cavity internally, lined with thick and horny epithelium. The pyloric opening is protected by a valve, and here are seen the orifices of the cæcal appendages which usually encircle the commencement of the small intestines." The muscular development of the 'stomach of the grey mullets—stronger perhaps than that of any other of our sea-fishes—is very striking; and one cannot help asking why a fish whose principal food consists of soft pulpy matter should have such strong muscular stomach walls. The grey mullet consumes such food as the mud or sand contains, or such as is attached to grass-wrack or sea-weeds. A great number of minute molluscs, often requiring the microscope or lens for their detection, are found within their stomachs. "In the profusion of specimens it affords, the stomach of one of these mullets is quite a store-house to the conchologist," writes Thompson. "From a single stomach" the same author says, "I have obtained what would fill a large sized breakfast cup of the following species of bivalve and univalve mollusca which had been taken alive—*Mytilus edulis*, *Modiola Papuana* (of these very small individuals); *Kellia rubra*, *Skenea depressa*; *Littorina retusa*, *Rissoa labiosa* and R. *parva*, *Serpulæ* and *Miliolæ*. Of these mollusca, specimens of *Rissoa labiosa*, three lines in length, were the largest and the *Kellia rubra*, from the smallest size to its maximum of a little more than a line diameter, the most dant. The only inanimate matter that appeared, were fragments of *Zostera marina* and *Confervæ*, which were probably taken into the stomach with the adhering mollusca. To this nutritious food may perhaps be attributed the great size this fish attains in Belfast Bay" (iv. p. 103). I expect that *diatomaceæ* enter considerably into the food which the mullets consume. Some fish consume *diatomaceæ* very largely indeed, notably the pilchard at certain seasons; and feeding as the mullet does on soft mud, it must swallow *diatomaceæ* to a considerable extent. I have, however, been unsuccessful in securing many specimens of this fish, and I await further opportunities. Of course the miscroscope, with a power of 200 to 400 diameters, is necessary for the detection of the *diatomaceæ*. The comformation of the œsophagus and stomach prevents the entrance of any food unless in a very small or comminuted state.

*Spawning.*—In the summer, end of May and June; the young in August are about an inch long; they appear in harbours in shoals, and are fond of entering fresh water, keeping above the tide, but returning as it recedes. Nothing is definitely known as to the deposition of the spawn. The grey mullet grows to the length of 18 or 20 inches, and will sometimes weigh 12 or 15 lbs. Day says it sometimes attains to upwards of 3 feet in length.

*Modes of capture.*—By set-nets, or trammel (double net), in Cornwall sometimes called a "tumbling-net;" a draft-net is also used when the water is low. It is said that near Belfast, in order to induce the mullet to enter the narrow inlets or "guts" where the nets are usually placed, it was customary to "spread cow-dung at or close to the water's edge as an attractive food which the fish will greedily devour." Mullet are sometimes caught with an artificial fly, or with a small red worm, or gentles. The tackle should be strong, for a large fish will struggle violently; a hook baited with a piece of the stump of a boiled cabbage, trailed through the water at a depth of about two or three feet, has been known to be a successful mode of taking these fish. Herring's roe has also been recommended, and I have somewhere read that an oyster is irresistible. In nets they are more readily caught during dark nights and at such times as they cannot see the net; indeed this, which is especially the case with the mullet, is to a considerable extent true of all fish. They are sometimes dexterously killed by a light spear or harpoon attached to a cord, something like an eel spear.

*Quality of flesh.*—This depends very much on the locality in which the mullets are caught; when living in very foul stagnant water it is not to be recommended. The flesh is nice-flavoured in fresh or salt water specimens, provided they can get abundance of oozy food and moving water. They thrive best in an admixture of salt and fresh water, where they can ascend and descend rivers. Sometimes I have thought the flesh hardly worth cooking, at other times very good indeed. They are often loaded with fat. They are in best condition in summer and autumn, and should be always eaten very fresh. They may be boiled or cooked in any of the ways in which it is usual to dress mackerel.

*Commercial value.*—Not caught in sufficient numbers or often enough to make them of much commercial value, and not generally, to any great extent, offered for sale in the markets. As this fish thrives well in freshwater lakes into which the sea-water at times gains admission, it seems to offer considerable inducement to cultivate it in suitable places.

*In confinement.*—The grey mullet is a fish which is very frequently seen in the tanks of our large aquaria, as at

Brighton, Westminster and Southport. Mr. Arnold of Guernsey, in 1831, communicated to the Zoological Society of London some experiments he had made with these fish in a five-acre lake of varying depths, having a muddy, gravelly, or rocky bottom, and which was chiefly supplied with fresh water. "Here for nine months in the year cattle came to drink, but in summer the water was too salt, due to a supply from the sea being received through a tunnel. The mullet bred here as freely as if they remained in the sea." In the Bull. Soc. Zool. d'Acclimat. 1867, pp. 190-200, M. Jean Vidal has written how mullets may be semi-domesticated and brought to a marketable size. Mr. Day saw a beautiful piece of water near Devonport, in 1881, into which a small stream flowed from the high ground above, while at its lower end a tunnel communicated with the backwater through which salt water obtained an entrance. A long weir prevented entrance to or exit from this lake. Here the grey mullets did well.

*Classical allusions and names.*—The ancient Greeks and Romans paid a good deal of attention to the grey mullets, and have recorded more or less accurately their habits. The usual Greek term of the grey mullet is κεστρεύς, but there are several other words which are used for this fish either in its varieties or according to the supposed quality of the flesh. Of the *cestreus* Aristotle, among other matters, says that it is usually found near the shore, and enters rivers, that it is not carnivorus, for it is never captured with anything of that nature in its stomach, nor is taken with a flesh bait, but with bread; that it eats seaweed and sand; that it is the most greedy of fish; that when its stomach is distended it is not good to eat; that it hides its head when alarmed, and thinks its whole body is concealed. Pliny (ix. 17) repeats this last assertion, and says that on this account the mullet (*mugil*) is a subject for laughter. He, as well as Aristotle (v. 4), asserts that in Phœnicia the fishermen use each sex for capturing the other; having taken the male *cestreus* they entice the female with it, and so enclose them in a net; they use the females in the same way for capturing the males. Aristotle remarks that the frequent observation of these circumstances appears to warrant this kind of intercourse among them. The grey mullet's cleverness in avoiding capture by the net is alluded to by Oppian (Halieut iii. 98–108) in these words: "The cestreus being urged forward by the encircling meshes of the net is not ignorant of the circumventing trick, for he mounts with all his strength to the top of the water, and strives by a nimble leap to raise himself aloft; nor does he fail in his cunning design, for oftentimes he has easily surmounted even the last of the corked lines and avoided death; but if he fails in his first attempt and falls again within the net, he no longer contends nor starts up, being grieved, but, learning experience from his (first) effort, he ceases from impetuous struggles."

Ovid credits the mullet with sufficient sagacity to rid itself of the hook from its mouth by a sharp blow of its tail:—

> "At Mugil cauda pendentem everberat escam
> Excussamque legit" (Halieut. 37).

"The mullet with its tail beats out the pendent bait, and snatches it up when thus struck off."

The ancient Romans kept grey mullet in their *piscinæ*, or fishponds, where they appear to have done well. Columella, after naming some fish which were considered not suitable for artificially constructed ponds, as being delicate and impatient of confinement ("servitutis indignissimum genus"), says, "I have often seen within the barriers (of the pond) shoals of the inert sea mullet" (De Re Rustic. viii. 18). Martial (x. 30) relates how at charming Formiæ (Mola di Gaëta) the angler had no need to go forth into the bay for his fish; they could be caught from the chamber and the couch. By being constantly fed the fish became tame and would readily take a bait. Mullet would come at their master's call. Of the soft roe and ova of the grey mullet the Italians make cakes called *botargo;* the milt or roe was pressed and salted, and smoke or sun dried; these cakes, exciting thirst, were used as an incentive to drink. Botargo was formerly eaten in this country. "Sir W. Pen came out in his shirt on to his leads, and there we stayed talking and singing and eating *botargo* and bread and butter, till twelve at night, it being moonshine; and so to bed very nearly fuddled." (Pepys' Diary, June 4, 1661.) The Greek word κεστρεύς was so named from its shape, κέστρα, a weapon with *a broad head;*" hence one of its Latin names *capito* (caput); from the idea that its stomach seldom contained food, it was also called νῆστις "the faster." Athenæus mentions a proverb, "The cestreus is fasting," applied to men who live honest lives and do not injure others, because the cestreus never feeds on other fish (Deipnosoph. vii. 78). Again, "For the most part he walks about without his supper; he is a *cestrinus nêstis.*" Our word mullet is from the Latin *mullus*, properly the "red mullet." The origin of the Latin term *mugil* is unknown. The specific name of *chelon* is the name of a certain kind of *cestreus* mentioned by Aristotle.

*General description.*—Height of body, 4½ to 5 in total length; snout obtuse; upper lip thick, two or three rows of papillæ; mandibles broad, the end of the maxilla behind and below the angle of the mouth; teeth small, a single row in each jaw; dorsal fin with four strong spines, the two first being equal in length. Pectoral equal the length of the head without the snout; ventral inserted between the origins of the pectoral and first dorsal fin. Tail fin forked; scales about 26 between the snout and the base of the first dorsal fin; colour, head and upper part of the back greenish, sides grey, abdomen silvery; six or seven parallel lines along the back and sides. *The inferior edges of the interopercula at the chin meet and leave a very narrow space uncovered on the lower jaw.* This, perhaps, is the most striking and readily seen mark of difference between this species and *M. capito,* where the above-named edges leave a wide space and meet for a short space posteriorly. The grey mullets, *Mugil curtus, M. septentrionalis,* Günther, and Donovan's *M. cephelus,* are regarded by Day as varieties merely of *M. chelo.*

### THE THIN-LIPPED GREY MULLET (*Mugil capito*).

*Mugil.*—Artedi, Gen. Pisc. p. 32; Spec. p. 71.

*Mugil capito.*—Cuv. and Valenc. xi. p. 36, pl. 308; Jenyns' Manual, p. 374; Parnell, F. Firth of F. p. 65; Yarrell, i. p. 234; Günther, Catal. iii. p. 439, and Stud. of Fishes, p. 501; Day, pt. iii. p. 230, pl. 46.

*Grey mullet.*—Couch, iii. p. 6, pl. 122.

*Geographical distribution.*—Occurs rarely on the Scandinavian coast, and only occasionally taken in the German Ocean; more common along the west and south-west shores of Great Britain; is found at the Cape of Good Hope; through the Mediterranean to the freshwater lakes of Tunis; and in the Nile as far as Cairo. On the shores of Ireland it is not at all common; Parnell includes it in his list of the fishes of the Firth of Forth; it is not, however, generally abundant anywhere in Scotland; it is better known, perhaps, off the Devonshire and Cornish coasts than anywhere else in the British Isles.

The remarks made concerning the thick-lipped grey mullet are generally applicable to this species, the thin-lipped grey mullet. There is said to be a difference, however, in the time of spawning; the *M. chelo* breeding in May and June, while this one is said to do so in the winter. This matter, however, requires further consideration. The most obvious difference between the two species has been already pointed out in the description of *M. chelo*. The *M. octo-radiatus* of Günther, Day considers merely a variety of *M. capito*.

## ORDER II.—ANACANTHINI. SPINELESS FISHES.

All the fin rays are articulated and have no spinous rays, with the exception of the genus *Gadopsis* (Australia and Tasmania); ventral fins, when present, jugular or thoracic; air-bladder, if present, without a pneumatic duct.

GROUP I.—*Anacanthini gadoidei*. Both sides of the head symmetrical.

GROUP II.—*Anacanthini pleuronectoidei*. Sides of the head unsymmetrical.

### FAMILY *Gadidæ* (Cuvier).

Body more or less elongated, covered with smooth small scales. From one to three dorsal fins extending along the whole length of the back, the rays of the last dorsal being well developed; anal fins one or two; ventrals jugular with several rays, but if the ventrals consist of mere filaments, as in *Phycis furcatus*, the dorsal is divided into two. Tail-fin free from dorsal and anal, but if united, as in

*Strinsia*, the dorsal has a separate anterior portion. Gill-openings wide, the membranes not being generally attached to the isthmus. Pseudo-branchiæ none or rudimentary and glandular; air-bladder and pyloric appendages present. Arctic and temperate regions of the Northern Hemisphere.

GENUS *Gadus*.—Body moderately elongate, with small scales; three dorsal and two anal fins, separate from the caudal; ventrals narrow, with six or more rays. Teeth in a band on the jaws; present on vomer, none on palatine bones or tongue; a barbel present or absent on the chin; branchiostegals seven; air-bladder present; cæcal appendages numerous. Seas of the Arctic and temperate regions of the Northern Hemisphere.

### THE COD-FISH (*Gadus morrhua*).

*Morhua vel Molva*.—Gesner, de Aquatil, p. 88.

*Asellus major*.—Willughby, p. 165, tab. L, M, 1, fig. 4.

*Gadus*.—Artedi, Spec. Pisc. p. 35, No. 6.

*Gadus morrhua*.—Lin. Syst. i. p. 436; Jenyns' Manual, p. 440; Cuv. Règ. Anim. Ill. Poiss., pl. 106, fig. 1; Thompson, Nat. Hist. of Ireland, iv. p. 178; Günther, Catal. iv. p. 328, Study of F. p. 540; Day, pt. iv., p. 275, pl. 78.

*Morrhua vulgaris*.—Fleming, p. 191; Yarrell, ii. p. 221; Parnell, Fish. of Firth of Forth, p. 173.

*Cod*.—Couch, iii. p. 53, pl. 135.

*Geographical distribution*.—The cod-fish is found on the coasts of Northern Europe and America, Iceland, and Greenland, southwards to New York. The general limit of latitude is from about 67° to 50°. Those found south of this limit are as a rule few in number, and those found north are inferior in quality. In Greenland the cod are said to be small, emaciated and voracious; but on the north-west coast of Norway, some degrees further north, cod-fishes are sometimes excessively abundant, and in season well-fed fish; there can be no doubt that this is owing to a better supply of food, and that this again results from the prolongation of the gulf-stream between Iceland and Norway, which tempers the cold water and renders it favourable to the development and growth of organic life. The east coast of Greenland, on the contrary, is washed by a cold Arctic current, and is therefore not suitable to the production of such food as the cod-fish requires. It is abundant in the North Sea, and extends along the coasts of the British Isles to those of France, and here it appears to have reached its *ultima Thule* of southern habitat; it is not found at all in the Mediterranean, and even on the coasts of Devonshire and Cornwall it does not appear to exist in any large quantities, and the flesh is decidedly not so firm and good as that of more northern fish. It is abundant around the islands to the north and west of Scotland, and is found in the Moray Firth at all times of the year, but is most plentiful in March. In Yorkshire it is abundant, and it is generally taken on the east coast, from Lincolnshire and Norfolk to the mouth of the Thames.

*General habits.*—Perhaps one of the most voracious and omnivorous fishes that exist. To Professor G. O. Sars we are indebted for much valuable information relating to the cod-fish; he has studied the life history of this fish and supplied many reports to the Norway Fishing Department. The cod-fish arrive along the north-west coast of Norway generally in the winter, often in large "schools;" and visiting the shores somewhere about the same time, they seem to come in numerous parallel lines, and in a north-east direction from the deep parts of the North Atlantic Ocean. The arrival of these schools is generally preceded by that of a large number of other small fishes of some kind, which the fishermen call by the name of "the announcing fish." We are not informed to what species or family these announcing fish belong; they come about Christmas time, and soon after the cod-fish make their appearance. These small fish are said to diminish gradually in numbers, and at last cod alone seem to remain. These periodic migrations continue up to March—the time, however, of course may vary according to the temperature or prevailing winds; a mild south-west wind bringing the armies of cod early to the shores. What are these announcing fish? Capt. J. W. Collins, in his account of the Norwegian fisheries (see 'Bulletin of the United States Fish Commission,' vol. i. p. 9, for the year 1881), speaking of the immense shoals of cod which visit the Lofoden Islands in the winter, says, "Toward the latter part of December the first schools appear upon the grounds along the outer side of the Lofoden group, and soon the 'coming in' fish are taken on those banks lying inside in the West-fjörd. The arrival of these fish, which are the forerunners of the countless millions that invariably follow, is hailed with great delight by the fishermen, many of whom resort hither from all parts of the country to engage in these fisheries." These "forerunners" appear to be distinct from the small "announcing" fish spoken of above. These schools consist of male and female spawning fish, at which time they are said to be very restless and disinclined to take the hook. In consequence of this they are taken with nets which will be noticed by-and-bye. After spawning, the cod leave the north coast of Norway and take a western course out to sea again, or extend in a southerly direction towards the North Sea, doubtless prompted by the search for food.

*Food of.*—Of a varied nature; and though perhaps having a preference for other fish, molluscs and crustacea, a hungry cod will swallow almost any substance which its capacious maw can take. Couch makes the following remarks on this subject: "The cod is one of the most voracious of fishes, and on most occasions appears to feed indiscriminately; yet there is proof that it exercises decided preference for particular objects; so that it is not only caught with some baits in greater abundance than with others, but there are animals likely to be found in its stomach, while there are others which it is vain to look for which still are of common occurrence in other fishes of the same family, which also gather their food from the ground. In addition to several sorts of bivalve shells and one or two species of aphrodite, stones are found of no small size, that have been swallowed, because of the encrusting lepralia or corallines that covered them; and when the latter have been digested, the stones are probably rejected from the stomach. In one instance six picked dog-fishes, each nine inches in length, were found in the stomach of a cod; and the following list of crustacean animals (crab and lobster kind) in the stomach of these fishes, which were taken in the west portion of the British Channel, will show the strong preference which the cod manifests for that sort of food; of which also, we may add, their digestion is so powerful and speedy, that in a short time after being swallowed, the hard and brittle part of the crust of the crabs is made so soft by the action of the gastric juice, that their legs may be twisted round the finger."

CRABS.—*Stenorynchus phalangium, Achæus Cranchii, Inachus, dorsettensis, I. dorynchus, I. leptochirus, Hyas coarctatus, Eurynome aspera, Xantho tuberculata, Cancer pagurus, Portunus corrugatus, P. arcuatus, P. marmoreus,* *P. pusillus, P. longipes, Gonoplex angulatus, Atelecyclus heterodon, Coryster Cassivelaunus, Pagurus Bernhardus.*

LONG-TAILED CRUSTACEANS, LOBSTER KIND.—*Galathea squamifera, G. strigosa, G. dispersa, G. Andrewsii, Munida Rondeletii, Gebia stellata, G. deltura, Nika edulis, N. Couchii, Squilla Desmarestii, Alpheus ruber, Scyllarus arctus.*

If pressed with extreme hunger, the cod will sometimes swallow any substance small enough for its throat. In one taken in Lynn Deeps in 1626, it is said, a book in three treatises was found and brought to the Vice-Chancellor of Cambridge; from another a bunch of keys has been taken; from another a partridge; from another a white turnip. Crustacean food appears to be the most nourishing food for fishes of any other kinds; the fish which feed upon them grow to a large size, are fat and have firm flesh.

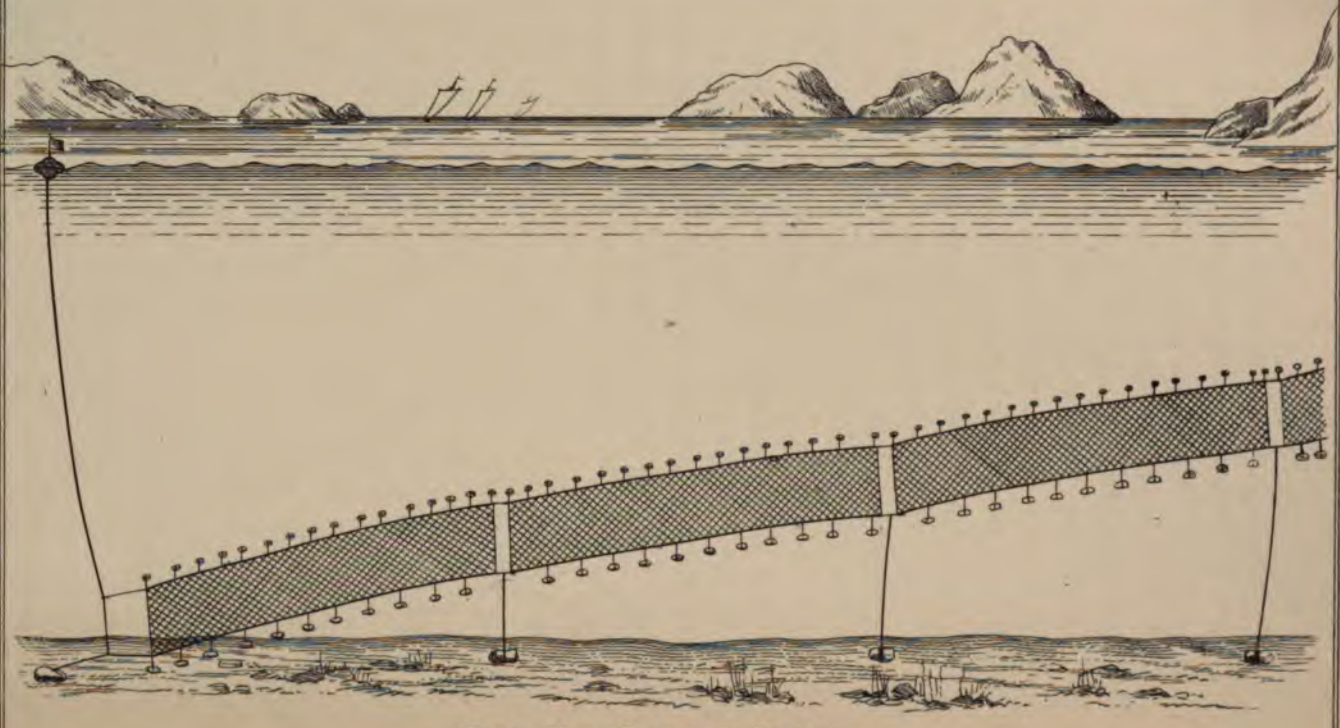
Sir Wyville Thomson visited the Faroe Islands during the cruise of the *Lightning* in 1868, and states that the banks there swarm with the common brittle-star *Ophiothrix fragilis*, with the Norway lobster *Nephrops Norvegicus*, large spider crabs, several species of the genus *Galathea*, and many of the genus *Crangon*. "So ample a supply of their favourite food," he remarks, "readily accounts for the abundance and excellence of the cod and ling on the banks." ('Depths of the Sea,' p. 60.)

*Spawning.*—Usually from January to March or April; depending probably partly upon the temperature, and partly upon the quantity of food the fish have been able to meet with in order to develop their ovaries. It was in the codfish that G. O. Sars first showed that the deposition of the eggs took place near the surface of the water, and that they float during the whole period of development. Cod are extremely prolific, and various calculations as to the number of eggs they contain have been made from time to time. As many as nine millions have been counted in a single fish. The females are generally found at the time of spawning to be nearer to the top of the water than the males, as shown by those caught in the nets, the males being taken in the drag-nets, the females in floating-nets. It would appear that in the cod there is no necessity for close proximity of the two sexes at spawning time; the ova float on the surface of the water on account of their light specific gravity; the heaviest part is that on which the micropyle, or small entrance for the admission of the spermatozoa, is found; and as this part is turned towards the bottom, the egg is able to receive through the micropyle the ascending spermatozoa of the male. But no time can intervene between the deposition of the eggs and their fertilization by the ascending milt, because they would soon imbibe water and thus be rendered incapable of receiving the fertilizing particles. The development of the embryo depends much upon the temperature of the water; the hatching in Sars' experiments occurred on the 18th day. In America it has been noticed to take place between the 13th and 50th days. Both the eggs and the hatched young float about on the surface of the water, being at the mercy of the winds and waves; and doubtless millions are eaten by such surface-swimming fishes as happen to be in the neighbourhood. After the absorption of the umbilical sac the little cod-fish must require food, and this must of course be of a very diminutive size; various kinds of entomostraca—perhaps also in their very young stage the small kinds of floating algæ, which sometimes form a scum on the water extending for many square miles—would supply the young cod-stomach with nutritious food. By the end of summer they are said to be about one inch in length, at times taking shelter under the umbrella-like disc of some jelly-fish. The habit of small fishes to take such occasional shelter has been recorded by several observers; and I have myself been witness to the same curious fact. What the object is I know not. Some writers believe that the fish resort to the medusa for the purpose of feeding on the minute creatures which it has killed or rendered inactive by means of its numerous urticating threads, and that in return for their hospitable entertainment the young cod-fish devours a small crustacean (*Hyperia*), which parasitically infests the jelly-fish. Hence this amiable friendship, hence this "umbrella courtship." But further observations on this strange connection between young fishes and jelly-fishes, or young fishes and sea anemones—for the same relationship exists here too—appear to be desirable. As the young cod grows it assumes the habits of the parent fish, and resorts to water nearer to the ground, frequents places where there is abundant growth of algæ, and where animal life of various kinds is at hand ready to supply them with food. In such localities they will remain and grow fast according as food is abundant; but it is not till the codling has left the shallow waters for the deep sea and there develops into a mature fish, that it can be held in any repute as excellent food. A good-sized, well-fed, full-bellied cod, with firm and flaky flesh, is, even without oyster sauce, very good eating, but a codling of from one to three pounds' weight is always more or less woolly, soft and insipid. The young fish are of different shades of colour, dark green, light green, dark grey, light grey, yellow or red, according to the colour of the ground and seaweeds where they are found. This is to be expected; the chromatophores in young fish quickly contract or expand, thus causing change in colour as one or other of the different coloured pigment-cells alters. Growth depends on abundance of suitable food. In the Southport Aquarium codlings of three-quarters of a pound in weight have increased in about sixteen months to six or seven pounds. Cod-fish grow to a large size. Specimens weighing 50, 60 and even 78 lbs. have been recorded. The last-mentioned weight was of a fish captured at Scarborough in 1755, and is mentioned by Pennant; its length was 5 ft. 8 in.

*Modes of capture.*—On our own coasts cod-fish are usually caught by line and hook baited with whelks, or 'buckies' as the Scotch call them, limpets, sand-launces, mussels, squid, &c. Whelks are most extensively used, and the procuring of this mollusc is a regular trade, small vessels being constantly employed. The cod-smacks, or "long-liners" as they are often called, are now generally provided with wells in the hull of the vessel, the sides of which are perforated with numerous holes so as to admit the ingress and egress of the water. Into these wells the cod caught on the lines are placed, and there they will live for many days or weeks while the vessel is out at sea. The long-line fishing is extensively used in the North Sea; at Grimsby this kind of sea fishing may be seen to perfection. A 'liner' takes out a complete set of these long lines; about fifteen dozen perhaps, forty fathoms deep; each line supports twenty-six hooks, which are fastened on smaller and shorter lines called "snoods," the snoods are tied to the main line about 8 or 9 feet apart so as to prevent their fouling one another. These fifteen dozen lines united form a "string" of 7200 fathoms (180 × 40) in length, nearly eight ordinary miles; and having 4680 hooks baited with whelk, which seems the best kind of bait used; it is attractive to the fish, and being very tough is not easily washed off the hook. The fishing is carried on during the daytime; the line is paid out, the smack being under easy sail, and after remaining for a few hours the hauling in begins. The line is kept steady by weights at every 40 fathoms or so; and conical shaped-buoys with a light pole and small flag fastened to the line at intervals show its position in the water. Cod are taken in the trawl occasionally, but not to any great extent. Netting cod has long been used in Norway, the nets employed being termed "gill-nets;" the method is said to have been introduced into that country about the year 1685; it is now extensively used at the principal fishing stations along the coast, but has its head-quarters in the great winter cod-fishery carried on at the Lofoden Islands. The cod, as already mentioned, come to the coasts from deeper water in immense shoals, full of spawn, from December to March; the principal bank being twelve miles from the land and having a depth varying from 40 to 80 fathoms. Being not disposed to take the hook the cod are caught in these gill-nets. No systematic kind of netting is carried on off our own shores. Now let us look at what is being done in Norway. "The total catch of cod at the Lofoden islands in 1878, according to the report of the superintendent, was 24,660,000 in number. Of these, upwards of 14,000,000 fish were caught with nets, 9,250,000 with lines, and 1,250,000 with deep bait. . . . . The superiority of the nets over lines and trawls, as shown by the respective earnings of the fishermen, has, as might be expected, led to an additional increase in that branch of the fishery. The larger amount earned by the net fishermen is due to the better quality of the fish taken by them more than to the increased catch, though this is also generally obtained. It has been found that the largest and fattest cod do not bite at the hook, but must be sought after with gill-nets, and it therefore follows that netted fish furnish a

X.-9.

Plate V.



Gill Net for Cod Fishing

very superior article of merchandise. . . . . In conclusion it might be stated that pollack are taken in gill-nets as well as cod. During the winter season large schools of these fish visit the coast between the 60th and 62nd parallels of latitude, and in the summer and fall are found on the coasts of Nordland and Finmark, where enormous quantities of them are taken by nets, trawls and hand lines. ('Bulletin of the U. S. Fish Commission' for 1881, p. 11.) The Americans are turning their especial attention to this gill-method of taking cod, which has been long in use to some extent in the Newfoundland fisheries. Professor Spencer Baird, Commissioner of the U. S. Fisheries, has taken the matter up, and it is probable that this method of catching cod will eventually be most successful.

These gill-nets may be briefly described as fixed "drift-nets;" that is to say, they are similar to drift-nets in general form, consisting of a wall of netting with meshes of various sizes. At the bottom of the net there are a number of weights at intervals to keep the net moored on the ground, the top line being furnished with numerous buoys to keep the net at its top part even throughout its entire length. At one bottom end of the net or at both ends a strong cord is fixed with a large buoy at the opposite end, which shows the places where the nets are set. (Plate V.)

These gill-nets may be set at the bottom of the water parallel with it, or they may be set in a diagonal position, one end of the net being near the ground, other portions being directed upwards and suspended in mid-water; or they can be so arranged that the whole net or series of nets occupies a position near the surface of the water; this is readily done by having mooring lines of different lengths attached to the bottom of the net. The fish push against the net and their heads are caught by the meshes, from which they cannot extricate their "gills." Hence the name of the net. A full description of the construction of these nets and their mode of setting may be seen in the 'Bulletin of the U. S. Commission,' already quoted. The principal English cod-fishery is carried on in the North Sea, especially on the Dogger Bank, from November to March or April, and on Cromer Knoll. In the months of March, April and May, long-lining nearly ends, and few cod are caught in the North Sea during that period. The fish are not then in good condition, having not recovered from spawning; in July long-lining commences again, and the Grimsby market may at that time be seen to be well supplied with cod in very good condition, and though fashion, or the absence of the concomitant oyster, prevents a very extensive use of this fish in a fresh condition, their flesh at this time is firm and excellent, and numbers are sold salted or dried as "stock-fish." The North Sea trawlers often go to Iceland and the Faroe Islands at this time and secure many cod, which are caught principally by hand-lines. The hand-line, which may be from 40 to 50 fathoms long, has a leaden sinker about 6 or 7 pounds in weight, with a stout iron wire, "the sprawl wire," fixed in it near the top, inserted at right angles near the top of the sinker, and then curving like a bow downwards; to each end is fixed a small line or "snood" with a large, strong baited hook, whelks being generally used. The baits are kept a few inches from the ground, where as a rule cod take their food, but should herring shoals appear the cod come near the surface. The fish bite best after sunset, when all hands are fully employed. The long-liners usually have five men to manage the boat and the fishing, but in the larger [illegible]s, which are about the size of trawl vessels, nine or even eleven men may be employed. The "welled smacks" cost more money—perhaps £250 or £300 more—than the dry-bottomed vessels of the same size, and their working expenses are greater. After the wells of the smacks are filled the vessels return home. The line fish are transferred into wooden chests about 7 feet long, 4 feet wide and 2 feet deep, which allow of the access of water; a number of these floating cod preserves may be seen in the docks at Grimsby; here they will live without losing condition for a fortnight, and when wanted they are taken out and killed, ready for the market or railway trucks, which are brought close to the docks.

*Quality of flesh.*—A cod in good condition is flaky, firm and well flavoured. Fashion has set its seal to the belief that it is not very good eating till October, and that Christmas fish are the primest. Of course much depends on the localities where they are caught, and the food they are able to get, but I can bear testimony that the cod in July and August are quite as firm and good as they are later on in the year, and the Grimsby fishermen and salesmen are of the same opinion. It is likely that they would be in good condition at this time of the year; they have recovered from spawning, they are very hungry, and they meet with swarms of various kinds of food which the sea has produced during the spring and summer months in endless profusion, in the form of young fish of many kinds, crustacea and molluscs. When abundant food exists for them in deep water away from the shores, the cod-fish can revel in such food without the necessary expenditure of force and waste of muscle entailed by long migrations from one place to another. When such mid-ocean food diminishes as the winter approaches, the cod, like other fish, are forced to move from place to place, and they advance nearer to the coasts in pursuit of such fish as tend thitherwards—these latter being themselves directed towards the same parts by the same search after food—partly because the neighbourhood of the coast affords more abundant food later in the year by reason of the seaweeds which afford shelter, and partly by reason of the food which large rivers near the sea-coast supply.

There is no need to say anything on the modes of cooking cod-fish; let a round, full fish be selected, let the pressure of the finger try the elasticity of the flesh. Always rub a little salt over the fish inside and outside; it is desirable to crimp it; let the fish be hung up for about a day in a cool, airy place to drain off any superabundant moisture, and you will find that you have been only throwing away your money if you have been in the habit of paying your fishmonger *4d.* or *8d.* a lb. more for *his* "crimped cod," whose opercula with their artistic scores and pictorial tattoos have hitherto beguiled your admiring eyes!

*Commercial value.*—The cod-fish is one of the most important fish in a commercial point of view that the seas of Great Britain and Ireland possess. It is not possible to form anything like a true conception of the quantities of cod captured during the course of the year, because statistics are only partially brought under the cognizance of the Fishery Officers, and because ling and hake are sometimes included with cod in the published abstracts. There is no return made for all the cod captured off the English coasts. The Scotch Reports include ling and hake; the Irish Report for 1881 gives the total quantity of cod exported to England from Ireland at 54,365 boxes of 2 cwt. each, the total value of which is estimated at £65,000, against the total of 57,101 boxes during the previous year of 1880. The value of the dry cod-fish of Newfoundland is stated to be on an average £400,000 per annum, while the total price of the exported productions in fish oil and skins is upwards of £700,000. The productiveness of the Norway fisheries for cod is immense. The total yield of the season in Norway, ending May, 1881, has been estimated as amounting to nearly 26,000,000 cod-fish, of which more than 21,000,000 have been salted. The cod may not be so abundant around our shores as around the Norway coast, but if gill-netting were resorted to, there would be a great increase of the fish caught in our seas and very little danger of their diminishing in any appreciable quantity by almost any kind of human agency that may be adopted for their capture, so prolific are the fish, and so limited the areas over which fishing can be carried on compared with the areas in which they exist.

*Diseases of.*—" The members of the cod family appear to be very susceptible to disease of the vertebral column, which may become shortened, and has been compared by Dr. Dyce to a form of rickets, occasioning angular or lateral curvature" (Day's 'Fishes of Great Britain and Ireland,' pt. iv. p. 274). They are said also to be often troubled with blindness. In the wide domain of the sea such instances of spine curvature or blindness are probably of small account. That curious parasitic crustacean, *Lernea branchialis*, may be often seen attached to the cod's gills; but it does not appear to be productive of much harm. Another parasitic crustacean of the order *Isopoda*, and family *Ægidæ*, the *Æga tridens*, is occasionally much more troublesome. All the members of this family are parasitic, and many of them upon fish; they live in the body of their host, and feed on the viscera and flesh. Multitudes of *Æga tridens* are sometimes found in the body of the cod-fish, and though the fish looks plump outside, when opened it is found to be full of these crustacea, which are in popular language called "bees."

The borer, myxine or glutinous hag (*Myxine glutinosa*) is in the Northern Seas of Europe a troublesome pest. This creature, wormlike in appearance, is a fish, allied to the lampreys (*Petromyzon*). The *Myxinidæ* have a similar distribution with the *Gadidæ*, and are frequently found in the abdominal cavity of cod-fish and other fishes. They penetrate into their flesh, which they devour, and in some parts of Norway and Sweden they seriously damage the fisheries. "The myxine descends to great depths, and is generally met with in the Norwegian Fjords at 70 fathoms, sometimes in great abundance" (Günther, 'Study of Fishes,' p. 695). Cod-fish on the British shores are not, however, much troubled with this formidable robber of the cod-liners; it grows to the length of fifteen inches or more. Pennant relates that the Scarborough fishermen often take it in the *robbed fish* on drawing up their lines. Cod-fish which have been left on the long lines or "bulters" for some hours, and have become dead, are the fish in which the myxine is generally found. It is supposed that this creature infests only dead species, and that it does not attack living fish. If this be the case the myxine is a less injurious enemy to other fishes than the sea-lamprey, which rasps the flesh of living fishes.

Parasitic entozoa cause more trouble to their piscine hosts than the epizoa, and often occasion considerable commercial loss. Diesing ('Systema Helminthum,' ii. p. 394) enumerates more than a dozen of these vermiform parasites, of which the genus *Agamonema*, perhaps, is one of the most common and most injurious. Cod-fish "out of season," in bad condition, with soft flesh, lean lanky bodies, requently spoilt as food by these worms, which, as in the case of the mackerel and haddock and other fishes, sometimes bore their way into the muscles of the flesh. A careful inspection of the boiled cod on your plate now and then reveals the presence of this very objectionable little beast.

*In confinement.*—Cod are very easily domesticated, become quite tame, and will come to the surface of the water in an aquarium and take food from the hand; will allow themselves to be stroked on the head and back, and seem to be quite pleased with the operation. It is said that they are liable to become blind if kept some time in an aquarium or excavated rock pool where perhaps there is too much light. The late Mr. Frank Buckland has given an account of a tame cod which he saw at Port Logan (in September, 1869), near Stranraer, Wigtonshire. Near the bottom of a garden at Port Logan House, the residence of General McDowall, the sea had hollowed out of the solid rock a kind of amphitheatre about 100 feet in diameter; the tide ebbs and flows through a chasm in the rock about six feet in width, so that the water was always pure. In this reservoir a number of cod-fish were kept. "From almost every side of the pond, and from its deepest bottom came darting towards us great open-mouthed cod-fish. They seemed to know personally Mrs. Towdie, the woman who is appointed as curator of the pond. She threw a mussel without its shell into the middle of the pond and in a moment the surface seemed boiling with struggling fish. . . . . I feel convinced," writes Mr. Buckland, "that fish—at least Gen. McDowall's cod-fish—have an intelligence for which we never give them credit. A cod's head and shoulders boiled, and put on the table with its forlorn and woe-begone features, is a very different thing from the head of a hungry cod in perfect health looking for his dinner. The eye has great power of motion, great quickness, and I should say an almost telescopic vision—of course in water. . . . . Having plenty of mussels and keeping very quiet, I made friends with these dear cod-fish. They all came quite up to the edge, just like chickens, to be fed" ('Familiar History of British Fishes,' pp. 127, 128). Mr. Buckland put a small viper which he had in his pocket into the water, but the fish all swam away from it. But "at last a big fellow came up from the bottom like a rocket and swallowed at a gulp about half of the viper. I pulled at the viper's tail and the cod pulled at his head; he was a tough viper or he would have come in two. At last the cod let go, as though he had found out that this was not his proper food."

The late Sir Wyville Thomson speaks of the tameness of cod-fish, as witnessed by him in specimens kept in a large square tank in the middle of a vessel at Faroe. "It is curious to see the great creatures moving gracefully about in the tank like gold fish in a glass globe. They are, no doubt, quite 'unaccustomed to man,' and consequently they are tame; and with their long, smooth, mottled faces, their huge mouths and lidless, unspeculative eyes, they are about as unfamiliar objects as one can see. They seem rather to like being scratched, as they are greatly infested by *caligi* and all kinds of suctorial copepods. One of them will take a crab or a large fusus or buccinum quietly out of one's hand and with a slight movement transfer it down into its stomach, where it is very soon attacked and disintegrated by the powerful gastric secretions. In one welled smack I visited on one occasion, one of the fish had met with some slight injury which spoiled its market, and it made several trips in the well between London and Färoe and became quite a pet. The sailors said it knew them. It was mixed up with numbers of others in the tank when I was on board, and certainly it was always the first to come to the top for the chance of a crab or a bit of biscuit, and it rubbed its 'head and shoulders' against my hand quite lovingly" ('Depths of the Sea,' pp. 59, 60).

Members of the cod-fish family occasionally enter fresh waters and live in them. It is well known that certain marine fishes are found in the northern part of the Baltic, where the water is very slightly saline; but from the southern portion of the Baltic, where the water is quite salt, these fishes are absent. Being marine fishes, it seems strange that as they wander from place to place they do not take a southerly direction towards the salt water, but seek a passage towards the north. Had those fishes found their way from the Arctic Ocean through the Sound, viâ the Skagerrack and Cattegat, one would suppose that the movements would rather be in a southerly direction than in a northerly one, but this is not the case. The fish in the northern part of the Baltic are smaller and thinner than the same fish in the Arctic Ocean. The probable solution of the question is that these north Baltic fish are the descendants of the fauna of the Glacial Ocean; that Finland and the middle of Sweden were during the glacial period submerged, and that the southern parts of the Baltic, now open water, were closed land; that the fish of the N. Baltic entered that portion from the Arctic Ocean by route of the then submerged parts of Finland and Sweden; that when later physical changes took place and that part of the Scandinavian continent became elevated, the N. Baltic fishes were cut off from entering the Arctic Ocean by a north route, and that the inherited instinct of moving northwards still remains, and to this day influences the descendants of the glacial fauna in this respect.

However, these fishes, which are chiefly inhabitants of salt water, have for ages continued to exist in water which has gradually changed from salt to fresh. What kind of fishes may be transferred from salt water to fresh, with advantage or without any injury to them, to what extent such fishes will multiply, grow and become good food readily obtainable, in artificial freshwater lakes, or lakes into which the salt water can flow, is a question well worthy of consideration and continued experiment. From an interesting communication from Lord Ducie to Mr. Day (Sept. 1881), it seems that cod-fish and other marine Gadidæ do voluntarily enter and reside in fresh waters. In a lake in the Norwegian Fjords, Lord Ducie caught with an artificial minnow a cod of 1 lb. in weight, next a coal-fish of 2 lb., then a pollack of 3 lb., and all these at the inland extremity of the lake, the pollack being actually in the snow-water stream. There was no sign whatever of a fresh-water fish. In short, the sea fish had complete possession of this lake, which was entirely fresh. Cod-fish have been kept for some time in salt-water ponds communicating with the sea, and are said to have improved in quality of flesh.

*Names.*—The derivation and meaning of the word *cod* are unknown. In Athenæus the Greek word γάδος, which is the same fish as the ὄνος, occurs, and this may be the hake; but the connection of our word cod with γάδος is very doubtful indeed. The Middle English *coddle* or *cod* means a "bag," or "bolster;" but the resemblance of this fish to a "bag" of any shape is very fanciful. In the Moray Firth the name of *poullach* is used, and *duncan* if the fish be half grown. *Poullach* or *pollack*, *pollock*, is doubtless of Celtic origin; but the connection of the cod-fish, whiting, or any of the Gadidæ with the Gaelic *poll*, a "pool," *pollage*, "a little pool," is by no means clear. The cod is sometimes called a *keeling*, *kleg* or *chelynge;* the two last words are archaic, they seem to be varieties of the same root, whatever that may be. *Codlings* and *skinners* are terms for young fish when about the size of a whiting; and when larger, *tumbling* or *tamlin-cod*. *Haberdine* is an old word for salted cod. *Stockfish* is used by Shakspere; cod-fish dried but not salted are still called stockfish. Gesner says that "stockfish is so called from the stock of wood ('a trunco') upon which this fish is placed in order to be pounded." Stockfish was considered poor and unsavoury food, but could be improved by good cooking. Cogan says, "Concerning which fish I will say no more than Erasmus hath written in his *colloquio*. There is a kind of fish which is called in English stockfish: it nourisheth no more than a stock. Yet I have eaten of a pie made only with stockefishe, whiche hath bene verie good, but the goodnesse was not so much in the fishe as in the cookerie, which may make that savoury which of it selfe is unsavoury. . . . It is sayd a good cooke can make you good meate of a whetstone. . . . Therefore a good cooke is a good jewel, and to be much made of." Muffett writes: "Stockfish whilst it is unbeaten is called buckhorne, because it is so tough; when it is beaten upon the stock, it is termed stockfish." A. Borde, in his 'Introduction to Knowledge,' under Islond (Iceland) says:

> "And I was borne in Islond, as brute as a beest;
> Whan I ete candels ends I am at a feest;
> Talow and raw stokefish I do love to ete,
> In my countrye it is right good meate."

"In stede of bread they do eate *stocfyshe*, and they will eate rawe fysche and fleshe; they be beastly creatures unmannered and untaught" ('Early English Meals and

Manners,' p. 98). Shakspere always speaks of stockfish opprobriously.

In Germany the cod-fish is called "Kabeljau" when fresh and old; "Dorsch" when young and fresh; "Stockfisch" when dried; "Labberdan" when salted. What may be the meaning of the specific names *morrhua*, *morhua*, and *molva*, it is difficult to determine; Gesner conjectures *merhuel; morhuel*, "sea-owl," and *molua* or *molva* from *mollities*, "softness," from the smooth skin (?).

Mr. Satchell gives the following provincial names of the cod: auld gibbie, beardie, chelynge, green-fish, greenling, haberdine, kabbelow, keelin, keeling or keling, kipling, knowl-cod, melwell, red cod, red wair cod, rock cod, skinner, slink, sprag.

*General description.*—Body more or less elongated, smooth, thickest anteriorly, belly tumid and soft; mouth very wide with a deep cleft; barbel rather long; snout more than twice as long as the eye, obtuse, upper jaw the longest; height of the body less than the length of the head, which is two-sevenths of the total, without caudal; vent vertical below the anterior rays of the second dorsal; the two anal fins separated by an interval; lateral line white, passing backwards from the upper edge of the orbit, curving downwards from near the end of the pectoral fin, and running straight to the tail; colour, greenish, grayish or brownish-olive, sometimes with numerous yellow or brown spots on the back and the sides. Varieties in colour occur. The *Gadus callarias*, Lin., "Dorse," appears to be a young state of the European cod.

### THE HADDOCK (*Gadus æglefinus*).

*Æglefinus* and *Ægrefinus.*—Bellon, pp. 126, 127.

*Tertia asellorum species.*—Gesner, pp. 26, 100.

*Onos.*—Willughby, p. 170, tab. L, M, I, No. 2.

*Gadus.*—Artedi, Syn. p. 64; Spec. p. 36; Gen. pp. 20, 21.

*Gadus æglefinus.*—Lin. Syst. Nat. i. p. 435; Lacép. ii. p. 397; Jenyns' Man. p. 441; Thompson, Nat. H. Irel. iv. p. 179; Günther, Catal. iv. p. 332; Day, pt. iv. p. 283, pl. 79.

*Morrhua æglefinus.*—Flem. Brit. Anim. p. 191; Yarrell, ii. p. 233; Parnell, Fish. F. of Forth, p. 177.

*Haddock.*—Couch, iii. p. 62, pl. 136.

*Geographical distribution.*—Having a range similar to the cod, inhabiting the North Sea, the British coasts, and the American shores of the North Atlantic, extending from Newfoundland to Cape Hatteras, 50° to 35°; common off the shores of Northern Europe, and very abundant in the North Sea; not so numerous as the cod in Orkney and Shetland; extensively taken in Banffshire, Aberdeen; more common on the east coast of Scotland and England than along the western; abundant in Yorkshire and Norfolk, and along most of the south coast of England, but not very plentiful on the S. W. as in Devonshire and Cornwall. Generally common in Ireland; Dublin Bay haddock are famous, and so are those of Belfast, where they are generally more highly esteemed than the cod.

*General habits.*—A very decided school fish, sometimes associating in enormous quantities; they are perhaps as voracious as the cod, but do not appear to mix with them. Haddock generally feed near the ground. They have been known to forsake old localities long frequented by them quite suddenly, and without any apparent reason. In

Dublin Bay and the neighbouring coasts the haddock in 1857 unexpectedly disappeared, and both trawlers and liners had their profits considerably diminished, and this was not the only occasion on which these fish became scarce. A similar sudden forsaking of long-frequented places has been frequently noticed off various parts of our coasts. After having been absent for a long or short period indefinitely limited, haddock revisit the same localities again. Of course the line fishermen laid the blame upon the trawlers and attributed to them the loss of the fish. The probable explanation of their forsaking long-frequented spots is to be found in their desire to obtain more food elsewhere. They are voracious feeders, but are not so omnivorous as cod-fish. From a great number of stomachs I have examined of fish caught in the North Sea, one especial favourite food seems to be sand-stars and brittle-stars (*Ophiuridæ*)*;* and where from some cause or another this or other prized food is diminished, the haddocks will migrate in search of it.

*Food of.*—As just stated the *Ophiuræ* are a very favourite food; crustacea are eagerly devoured, molluscs and small fishes. I found those I examined from the North Sea last July to be crammed full of *Ophiuridæ*, chiefly of the commonest species of brittle-stars, the *Ophiocoma rosula ;* sand-stars (*Ophiura texturata*) were also frequent. The whole stomach and intestinal tract were literally crammed with these creatures; and one wondered how the fish could draw sufficient nourishment from creatures so fragile and fleshless. Thompson's evidence is entirely in accord with my own. He says: "Many examples purchased by Dr. J. L. Drummond and by myself in Belfast market during one season contained only the remains of *Ophiuræ* and were almost invariably filled with the most spinous species of this genus, *Oph. rosula.* In his valuable papers on the Irish *entozoa*, published in the 'Mag. Nat. Hist.,' Dr. Drummond attributed the absence of intestinal worms in the haddocks which he had examined to the circumstance of the stomach and intestines of the fish containing the spines of *Oph. rosula.* Almost every haddock that I have opened had the stomach and intestines filled with the remains of *Ophiuræ*" (Nat. H. Irel. iv. p. 180). A footnote by the Editor states that Thompson's MS. contains full notes of the various kinds of food which this naturalist had found in 119 haddocks examined during a period of sixteen years. In 102 of these fishes were fragments of *Oph. rosula*, which in many instances filled the stomach. Other species of the *Ophiuridæ*, small crustacea, shells, a few sea-mice (*Aprodita aculeata*), Nereidæ, sea-urchins, one actinia, two small fishes and a young herring constituted the remainder of the food. No doubt haddock, like other fish, can to a certain extent adapt themselves to eat various kinds of food in the absence of those particular kinds of which they appear to be more particularly fond. Again, the quantity of some particular food in the stomach does not *of necessity* imply a partiality for that kind on the part of the fish, because it may so happen that the food found in the stomach is that kind which principally occurs in the places frequented by the fish, other kinds being not so abundantly represented. Still the presence of some particular food in the stomach generally implies the fish's fondness of it.

The strong muscular walls of the haddock's stomach lead to the supposition of hard food entering largely into its diet; but even here one cannot hastily generalise, because, as I have observed in the case of the grey mullet, a strong muscular stomach co-exists with a very soft diet.

Again, the very firm quality and even dryness of the flesh of the haddock presupposes a hard and firm diet.

*Spawning.*—The spawning process of the haddock has been shown by George Ossian Sars to be very similar to that of the cod; January, February and March being the general months; the ova float near the surface; the time required for hatching is probably variable according to temperature. In America, where much attention is paid to the haddock fishery, spawn fully ripe has been found within the fish about the middle of March. The average time required for hatching is said to be nine days. An ordinary sized haddock may weigh from two to four pounds, but larger specimens are sometimes caught. In Belfast Bay a haddock of as much as eighteen or twenty pounds has been taken; Pennant mentions one fourteen pounds in weight, and speaks of such fish being extremely coarse. In the higher latitudes the haddock attains a length of three feet.

*Modes of capture.*—By the trawl chiefly, but also by the line. I have seen enormous quantities caught in the North Sea; a third of the contents of the trawl would often be haddock. On the south and south-west coasts of England haddocks are not common; the Brixham and Plymouth trawlers do not specially look for them; I saw but few when I visited these places in October, and saw none brought up by the trawl in any expedition, but a few haddocks sometimes of a large size are taken at Brixham. Fish taken with long-lines and hand-lines—the hooks being baited with pieces of herring, sand-launce, squid, or with mussels and pieces of whelk—are supposed to be better than trawled haddock. I do not think there is any real difference in the quality of the flesh between trawled and lined fish. Fish are very rarely injured by the trawl;

though the "liners" make complaints, seeking thereby to enhance the value of their own captures. The long lines used for haddock-fishing off Norfolk are about 370 fathoms in length. Haddock are usually found near the bottom, and in deep water deep lines are necessary.

*Quality of flesh.*—Firm and commendable, but inclined to be somewhat dry; they are in good condition nearly all through the year, from May to February; and are only inferior about the time of spawning in March and April; they soon recover from the effects of spawning. The very large fish are not generally considered as good as those of a medium size; but in the Irish markets the larger the haddock the more it is prized, according to Thompson, who also says that he never met with a finer-flavoured fish than one of 10 pounds, of which he partook. Enormous quantities of these fish are cured in many parts of the country. The well-known Finnan haddock are cured in the neighbourhood of Aberdeen, and have a deservedly good reputation. In London much of the curing process is carried on by the costermongers of Billingsgate on the Surrey side of the Thames, in the neighbourhood of Camberwell, Walworth, and Kennington. The haddocks are brought into an enclosure, and boys and girls cut off the heads and tails, split them open, clean them, and plunge them into the pickling tubs, where they soak for three hours, and then the "skewering-up" process begins. Through each fish a peeled rod is passed until the rod is full; they are then laid on ledges in rows. A fire is kindled underneath, which is kept smouldering by the judicious application of sawdust. The "curing-house" is now closed up, and when the fish are sufficiently tinged of a yellow colour they are considered to be ready. Six to eight hours is sufficient time for a skilled curer to split, salt and smoke a load of haddocks fit for sale. The Aberdeen haddock are not always submitted so long as others to the smoking process; are whiter and less smoky in flavour, but of course will not keep so long. Before cooking, split haddock should be always soaked for half an hour or an hour in cold fresh water.

*Commercial value.*—The haddock is a very valuable fish, both for the good qualities of its flesh, and its great abundance in many parts of our coasts. The superior sole, turbot and red mullet throw the haddock into the shade in a strictly commercial point of view as to price, and haddock are by the trade still designated with some other fish as "offal," the aristocratic fishes above named with salmon, salmon trout, &c., claiming the title of "prime." Nevertheless, the haddock really constitutes one of our most valuable fishes as food for the people. The wholesale price of "live haddocks" at Grimsby, where a great number are brought to market, ranges from 6*s.* to 14*s.* per score. The ordinary retail price of smoked haddock is 5*d.* per pound.

*Names.*—The origin and derivation of our word *haddock*, like several other fish names, remain uncertain. The Gaelic *adag* is probably borrowed from the English word; Professor Skeat conjectures the suffix *ock* to be a diminutive like *hill*, *hillock;* the base *had* certainly looks like γάδος; the haddock being "the little cod," and this seems to be a probable explanation of the word, which may be signified by Muffett, p. 153. "Haddocks are little cods, of light substance, crumbling flesh and good nourishment in the summer time, especially whilst venison is in season." In Scotland the haddock after spawning is called a *gamrel* or *camrel;* young fish about 5 inches long are called *hockies.* Mr. Satchell in his provisional "Index to a

Glossary of Fish Names," gives those of "Pin the Widdie," "Powee," "Rizzered Haddie." Parnell gives the name of "speldrings" for dried haddock. The specific name of *Æglefinus* is a barbarous Latinised form of "eagle" and "fin." Gesner thinks that *eagle-fish* ought to be read instead of *eagle-fin*, "rostro aquilino," but the fish's snout bears no resemblance to the beak of an eagle or any other bird. I have little doubt that the name refers to the shape of the first dorsal, which, as also in the allied species the "Bibs" (*Gadus luscus*), is pointed at the extremity, and in form bears a resemblance to a bird's wing. The haddock, with the dory, has been supposed to be the fish which St. Peter took at the command of Christ. Superstition imagined the large black patch on the haddock's shoulder to be the impression left by the Apostle with his finger and thumb. Considering that the fish of the narrative is said to have been taken out of the Lake of Gennesaret, the identification with the haddock or dory is quite out of the question ; but superstition, especially when connected with religion, is generally altogether regardless of possibilities.

*General description.*—Height of the body 4½ to 6 in the total length ; snout projecting and rounded ; the upper jaw being rather the longer ; the first dorsal pointed anteriorly, and somewhat triangular ; short interspace between the first and second dorsal fin, also between the second and third dorsal, which is not continuous with the caudal ; the two anal fins separated by an interspace ; the second anal being also separated from the caudal ; ventral fin pointed and inserted on a line anterior to the base of the pectoral, which is also pointed ; scales small but distinct ; lateral line black and distinct, curving gradually downwards below the second dorsal. Colour, greyish on the back, lighter on the sides, and white beneath ; a large black oval patch between the pectoral and first dorsal. Fins, bluish-black. Barbel very short.

### THE BIB, POUT OR WHITING-POUT (*Gadus luscus*).

*Asellus luscus.*—Willughby, p. 169; A. mollis latus, Appen. p. 22, tab. L. M. i. 4.

*Gadus.*—Artedi, Spec. Pisc. p. 37, No. 12; Syn. p. 65, No. 6.

*Gadus luscus.*—Lin. Syst. Nat. i. p. 437; Jenyns' Manual, p. 442; Thompson, Nat. Hist. Ireland, iv. p. 181; Günther, Catal. iv. p. 355; Day, pt. iv. p. 286, pl. 80.

*Morhua lusca.*—Flem. Brit. Anim. p. 191; Yarrell, ii. p. 237; Parnell, Fish. of F. of Forth, p. 180.

*Bib.*—Couch, iii. p. 70, pl. 138.

*Geographical distribution.*—Scandinavia; along the Atlantic coasts to the British Isles; France, Spain and Portugal; but not so frequent far southwards, and not generally abundant in the Mediterranean, though stragglers have been taken in Italy. Common near the mouth of the Thames; probably found all round the English coasts. It is very common off Devonshire and Cornwall during the autumn and winter. It occurs in Zetland, is said by Edward to be common in Banffshire, where it is generally used as bait. According to Thompson, the bib is of occasional occurrence on all quarters of the Irish coast, and specimens may be seen at every season of the year in Belfast market, but rarely more than one at a time; they are brought from the Antrim and Down coasts. Off the Dublin coast it is said to be one of the commonest fish.

*General habits.*—The bib appears to be less a wanderer than most of the Gadidæ, adhering pertinaciously to one spot. According to Mr. Dunn, it is largest and in best condition when residing among rocks, as on the precipitous coasts of Cornwall. Couch also remarks that its chief resort is rocky places, where it finds congenial food in the multitude of small fishes and crustacea which frequent such localities. Day writes that the bib "seeks a secluded crevice or gully, where it conceals itself during the day-time, sometimes thousands seeking the same spot. At twilight it sallies out, as it usually feeds only at night time, extending its excursions over the high grounds and on to the low rocks and sands beyond, but not going very far." It may be that the bib feeds principally at night; but I have seen numbers caught in the Brixham Harbour during the day by hook and line. Assemblages of these fish are known as "bib-chains." In mild winter it remains near the coast, but if the weather be severe it retires into deeper water, visiting the shores again in the spring. Mr. Day observes that it appears partial to living inside wrecked vessels.

*Food.*—Crabs and other crustacea, as prawns and shrimps, when they frequent sandy places. I have found in the stomach small hermit-crabs which had been swallowed when they had been without their usual shell-houses.

*Spawning.*—Probably in March or earlier. Thompson found the roe very large in a female, 15 inches in length, on the 10th of March. Day says that in Cornwall it spawns towards the end of winter. Doubtless the spawning time depends to some extent upon the temperature. The mode of deposition of the ova is not known. The ovum is said by Thompson to be $\frac{1}{3}$ less than ordinary sized clover seed; the usual size of the bib is from 9 inches to a foot in length; but they grow to 15 or 16 inches, and attain sometimes the weight of 4 pounds.

*Modes of capture.*—By line-fishing, often from a small boat, in the vicinity of a harbour. The bib is a voracious fish and bites freely; a piece of squid, small fish, or lugworm may be used as bait; a small hermit-crab is a very enticing lure. Bibs are often also caught in the trawl-nets. The summer and autumn are the best seasons. In Dublin Bay it is said to take the bait best on a sunny afternoon at low water; Buckland says that excellent fishing can be obtained near Portsmouth, and that the pouts crowd round anchored ships at Spithead, and feed on the refuse thrown overboard.

*Quality of flesh.*—Very good indeed when taken fresh from the water. I consider it not inferior to the whiting. It is in good condition from August to November. Yarrell justly says the flesh is excellent. It is good, either boiled or fried.

*Commercial value.*—Seldom seen in the markets, and not caught in sufficient numbers to make it of much general value. Those who happen to be near the sea in places where the bib is caught should purchase; the price is small and the food, as already stated, excellent. It is said not to keep well, and that this fact detracts from its value.

*In confinement.*—The bib is said to thrive well in an aquarium and to assume a lighter colour.

*Names.*—In front of the eye of the bib there exists a loose bag, capable of inflation, and formed by two membranes; this membrane the fish has the power of distending; after death it often becomes opaque, and has a blind-blister-like appearance. From this appearance the bib has received its name; other names expressing in popular languages the same thing are in use, such as *blain*, *blen*, *blind*, *pout*, *pouting;* it is called *smeltie* in Zetland, *kleg* at Scarborough, *brassie* in Scotland. The unpleasant name of *stink-alive*, which Buckland mentions, refers to its soon losing its freshness. *Lug* and *bothock* ("leaf" and "large eyes") are said to be Cornish names of this fish (Day). Females at Belfast are called *hen-fish* (Thompson).

*General description.* — Body broad in comparison with its length; the height being one-third of the total length without caudal; snout obtuse; upper jaw slightly the longer; barbel as long as the eye; first dorsal fin elevated; no true interspace between the first and second dorsal; second anal similar to the third dorsal; ventral fins long and pointed, in advance of the pectoral. Lateral line slightly curving about the middle of the second dorsal, then straight to the tail. Colour of the back, reddish-brown or dusky yellow; sides bronzy, sometimes with cross irregular broad bands; a conspicuous black spot at the base of the pectoral fin. Fins darkest at their outer edges.

The Power or Poor Cod (*Gadus minutus*) is chiefly noticeable as a guide to the fishermen, as being the fore-runners of haddock and cod; it is a small species, and of no commercial value.

### THE WHITING (*Gadus merlangus*).

*Secunda Asellorum species.*—Gesner, pp. 85, 99.

*Asellus mollis major.*—Willughby, p. 170; tab. L. M. i. 5.

*Gadus.*—Artedi, Spec. Pisc. p. 341, No. 1; Gen. p 19.

*Gadus Merlangus.*—Lin. Syst. Nat. i. p. 438; Lacép. ii. p. 424; Cuv. R. Anim. Ill. Poiss. pl. 106, fig. 2; Günther, Catal. iv. p. 334; Day, pt. iv. p. 290, pl. 82.

*Merlangus vulgaris.*—Flem. Brit. An. p. 195; Jenyns' Manual, p. 445; Parnell, Fish. Firth of F. p. 182; Thompson, Nat. H. Irel. iv. p. 182; Yarrell, ii. p. 244.

*Whiting.*—Couch, iii. p. 74, pl. 140.

*Geographical distribution.*—The coasts of northern Europe; generally occurring on all the coasts of England and often abundant on the west and south. On the Devonshire coast it occurs in great quantities, and the fish are often of a large size. Not common in the north of Scotland, and not often met with in the Orkney Islands; often taken in Banffshire, but not considered so good as the haddock. Abundant in the Firth of Forth. In Ireland it is taken round the coast, but is not held in much estimation in the north, where it is sold at a cheap rate. Those caught on the Norfolk coast only attain to about two-thirds the size of those of Devonshire and Cornwall (Day).

*General habits.*—Whiting are to be found during the year all round our coasts, but more abundantly in the early months of the year, when they approach the shores during spawning time. They swim in large schools, but do not usually come near harbours, keeping from one to four miles from the shore. They seem to be susceptible to cold. Couch observes that on one occasion it was noticed that large numbers were on the coast, the largest with full roes and milt, in February; that on the thermometer falling from 47° to 44° the whole of the larger fish went into deep water out of the reach of the fishermen, though the weather was not stormy. Whitings are, like the Gadidæ generally, voracious, and change their quarters in pursuit of their prey, especially the young of other fishes, of which they are very fond. In the autumn they are very abundant on the Devonshire and Cornwall shores, pursuing the young pilchards and herrings which frequent the bays.

*Food.*—Young fishes, crustacea, squid, molluscs.

*Spawning.*—In the early months of the year, the time varying according to the temperature. The eggs have been proved to be deposited at the surface of the water, where they float and develop. Probably the generality spawn in March. The usual size is from 12 to 16 inches; but large fish of 3 or 4 pounds are not unfrequently taken. Pennant speaks of whiting caught on the Dogger Bank from 4 to 8 pounds in weight.

*Modes of capture.*—By line-fishing, the hooks being baited with pieces of squid, or a slice of herring, or a mussel. I have used cockles and slices of sand launce successfully. Some of the line-smacks take with them very long lines, having 150 or 200 each, and one vessel will set twenty of these bearing from 3000 to 4000 hooks. Whiting are also taken by the trawl. They are said to bite best early in the morning or in the evening, but not generally after sunset except on moonlight nights. Enormous shoals of whiting sometimes appear in the Southampton Waters; as many as forty or fifty dozen have been caught from a boat in an afternoon, with only one man to attend to the lines.

*Quality of flesh.*—Superior, perhaps, to all the other species of this valuable family; the flesh is flaky, firm and not dry, very easy of digestion, and of excellent flavour. The fishermen always gut them before packing for transmission to the various markets, for the flesh rapidly deteriorates; the fresher it is cooked the better. Those that have been kept for some time are salted and dried and have received the name of "buckhorn." Willughby speaks of whiting being thus prepared and as affording "most excellent food to delicate palates." He also states that the Germans and Belgians in the preparation of these fish use the root of *curcuma* (turmeric) to bring out the flavour and give a yellow colour to the flesh (p. 171). In John Russell's 'Boke of Nurture,' "garlec or mustard, vergeus (verjuice) and pepper," are recommended as "moost metist sauce for whytynge, hake, stokfyshe, haddock, & cod." At the present day we prefer whiting fried, boiled or baked.

*Commercial value.*—One of the most deservedly prized of all the codfish family, and in general request. Perhaps with the exception of the mackerel there is no fish that is more liable to suffer from packing and carriage; consequently when large numbers are taken they are sold at a small cost. The ordinary price of dead whiting is from 4*d.* and 6*d.* per pound wholesale at Grimsby.

*Names.*—The whiting derives its name from the white colour of its body and flesh. *Buckhorn* is an archaic word applied to dried whiting and haddock. *Mop, whiting-mop,* are young whiting; mop is a term formerly used of any young animal, and even a young girl was so called. It is difficult to see its meaning as thus used. The French "Le Merlan," and the Latin specific name of the whiting, *merlangus,* is from the Breton *marlouan,* the root of which word is unknown.

*General description..*—Barbel absent, height of the body 5¼ to 6 in the total length; snout conical; interorbital space nearly flat; first and second dorsal fins separated by a short interspace, the same between the second and third; ventrals inserted before the line of the base of the pectoral, which is about half the length of the head; scales small and cycloid; lateral line curving gently downwards near the commencement of the second dorsal, then straight to the caudal, which is truncated; colour greenish-grey or yellowish, silvery on the sides and belly; a black spot in the axil of the pectoral fin.

### THE COAL-FISH (*Gadus virens*).

*Piscis Col-fish Anglorum.*—Gesner, p. 89.

*Asellus niger*, Colefish *Septentrionalium Anglorum.*—Willughby, p. 168, tab. L. M. i. No. 3.

*Gadus.*—Artedi, Spec. Pisc. p. 34, No. 2; Gen. p. 20, No. 2.

*Gadus virens.*—Lin. Syst. Nat. i. p. 438; Günther's Catal. iii. p. 339; Donov. Brit. F. i. pl. 13; Day iv. p. 293 pl. 84.

*Gadus carbonarius.*—Lin. Syst. Nat. i. p. 438.

*Merlangus virens.*—Flem. Brit. Anim. p. 195; Jenyns' Manual, p. 447; Yarrell, ii. p. 250.

*Merlangus carbonarius.*—Flem. Brit. An. p. 195; Parnell, Fish. Firth of F. p. 185.

*Coal-fish, Green Pollack.*—Couch, iii. pp. 84, 87, pl. 143, 144.

*Geographical distribution.*—The North Atlantic, coasts of Scandinavia, North Sea, around the British Isles to the shores of France, in the Mediterranean; abundant in the North Sea, the Orkneys and Shetland, in Banffshire, St. Andrew's, in the Moray Firth when the herrings are present; common on the Yorkshire coast. It also occurs on the North American coasts. In Devonshire and Cornwall it is common during the winter and spring. Common in Ireland, but said to be rare in Dublin Bay.

*General habits.*—A very bold and voracious fish, gregarious; it snatches at a bait with headlong eagerness, and often swims close to the surface; very swift in motion, and sporting with the same energy that it devours. The lively play of the coalfish near the surface of the water is thus described by Dr. Drummond as witnessed by him near Larne: "The whole sea about the boat was alive with them playing about in all attitudes, with a rich evening's sun illuminating their sides. They never minded the boat going among them, being intent only on their gambols, and were drawn into it in numbers with an instrument like a boat-hook." Mr. Dunn, who has noticed these gambols, considers that at this time they are chasing small fishes.

*Food of.*—Other fish of various kinds; crustacea, cuttle fish or squid, small crustacea as *Idotea* and *Oniscus*, with which Dr. Drummond found their stomachs almost invariably full; they are very destructive to herrings. Mr. Ffennell saw twenty-six young salmon once taken from the stomach of a colefish.

*Spawning.*—In March and April; the ova are emitted near the surface, and undergo development there. Day says that the eggs appear to hatch in four or five days in water of moderate temperature. Small fry forming vast shoals of fish about 1½ inches in length have been seen off the Orkneys in June, and in July off Yorkshire; by August they have attained the size of 3 to 5 inches, and will then take a baited hook. Coal-fish are very prolific of eggs; as many as 4,000,000 have been counted in a fish about 40 inches in length. They grow to the size of more than 40 inches. "In Belfast Bay a few large examples of this fish are not unfrequently taken in mullet-nets, in the spring of the year. I have seen them of 25 and 30 pounds so taken. The largest specimen taken in Belfast Bay, of which I ascertained the weight, was 32 pounds, this fish was 2 ft. 9 in. in length. Two others, captured in the month of December, of which I took measurements, must have considerably exceeded that weight, as they were each 3 ft. in length and a foot in depth, not reckoning the curve of the body; they were in high condition, well-shaped and firm. I have noted a few other examples here 3 ft. in length; these last were taken in mid-winter" (Thompson, Nat. H. Ireland, p. 182).

*Modes of capture.*—Principally by line-fishing; the larger fish are caught often far out at sea, but the smaller ones near the shore. Slices of herring, sand-launces, squid, lug-worms, are used to bait the hooks, or pieces of whelk. A few are caught by the trawl or in the drift-net. A boy fishing from a projecting rock may sometimes catch young coal-fish as fast as he can bait the hooks and pull them out. Small specimens will readily take a fly, made with a bit of white feather fastened on the hook. Strong currents seem a favourite locality for coal-fish; near the Start light-house hundredweights have been taken in a single early morning with baited hooks. Around the Isle of Wight also many are thus captured.

*Quality of flesh.*—Not in much estimation in a fresh state; more valuable when salted. The smaller fish are soft and insipid, inferior to a codling, which in this state has also little to recommend it; the larger coal-fish are better, and if cooked immediately after capture are fairly commendable.

*Commercial value.*—Not high; at Grimsby they sell from about 20*s.* to 60*s.* per score. They are in good condition from July to October or November. The greatest coal-fish fishery is among the Orkney Islands. Full-grown fish are called *saith.* They are fished for chiefly in very rapid tideways where there is much broken water, and the fishing is frequently attended with accidents to the boats. The fish average from 15 to 20 pounds, but larger examples are often taken. "When cleaned and dried on the rocks, about 17 will weigh one cwt., and yield three gallons of oil, which is equivalent to 340 fish and sixty gallons of oil to the ton. The dried article sells at market for about £12 per ton, when cod-fish fetch £20 per ton, but the extra quantity of oil in the former far more than compensates for the difference in price, and consequently when a shoal of saith sets in, the fishermen invariably desert the cod-fishing in favour of the other. Dried saith are perfectly well known in the market and are tolerably good eating, though inferior to cod" (*Land and Water*, Dec. 8, 1866).

*In confinement.*—Jesse in his 'Gleanings' (p. 39), relates, of some large coal-fish kept in a small pond into which sea water could be introduced, that "they became bold and familiar, floating about slowly and majestically, till some food was thrown to them; this they seized voraciously, whether it consisted of shell-fish or ship biscuit. They also would occasionally approach the margin and take their food from the keeper's hand."

*Names.*—The names of the coal-fish are almost legion. The ordinary name is derived from the blackness of colour, which is often very decided, contrasting strongly with the silvery white lateral line. Many of these names have reference to the colour of the fish, as *blue-backs* (Yorkshire), *black pollack*, *blue jack*, *coalsey*, *coal-whiting*, *colemie*, *green cod*, *green pollack*, *grey lord*, &c.; *cuddy* and *cooth* may refer to the close, gregarious habits of the young fish; *glassock*, *glassan*, *glossin*, to the shining skin; the *rauning pollack* of Cornwall is the ravening pollack. Several other names occur, the meanings of which are not clear; thus we have *baddock*, *billet*, *dargie*, *gilpin*, *gull-fish*, *harbine*, *kuth*, *lob*, *lob-keeling*, *moulrush*, *piltock*, *podlie*, *podling*, *prinkle*, *parr*, *saithe*, *sillock*, *stenlock*, *tibrie*. Mr. Satchell is at work in fish names and will doubtless throw some light on some of their meanings.

*General description.*—Height of body 4¼ to 5 in the total length; snout conical; lower jaw projecting. Barbel rudimentary or absent. Teeth in the jaws cardiform; interspaces between the three dorsal fins, the third not extending to the caudal; second anal similar to the dorsal. Caudal truncated or slightly forked. Lateral line distinct and white. Colour, upper part of the head and body above the lateral line black, lighter below the lateral line; colour on back varies, sometimes dark grey; belly silvery, mouth black, fins grey, dorsal and caudal with dark edges.

NOTE.—The coal-fish is known in America by the name of pollack. The Bulletin of the U.S. Fish Commission for 1881 (vol. i. pp. 342, 343) gives some interesting particulars on "Pollack Fishing in Boston Bay." The communication of Mr. S. J. Martin to Prof. Baird shows how closely packed these fish sometimes are, and perhaps explains one of the popular names of the fish, *i.e. cuddy*, "cooth" = "to cuddle," lie close together; Dutch, *cudde*, "a flock;" Old Dutch, *cudden*, "to flock together." The letter states that "there is not a rocky spot in Boston Bay that has not plenty of pollack, although there is one particular place where the vessels all anchor. This is called the old 'South-East.' I have seen 75 sail of vessels at anchor in a place half a mile square. They lie so near together that they take the oars to push the vessels apart, and they have seines from one to another; with a sudden change of wind they have to cut cables to get clear. When it is moderate some of the vessels make fast to the vessels at anchor. Most of the vessels carry ten men each. They fish with two lines to a man. Some of the vessels have caught 30,000 pounds in 24 hours. They use some fresh bait, but mostly clams; the older the clams the better. They use clams that have been carried to the Banks. There are 40 sail of eastern vessels up here fishing for pollack. Sometimes in a clear night they catch as many as they do in the day. The per

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Yorkshire coast. It is a common species around the coasts of Ireland.

*General habits.*—Prefers rocky parts of the coast, generally not far from the land, lying in wait on that side against which the tide happens to be blowing for any prey that may come within reach; generally seeking their food not far from the bottom but often swimming in mid-water; keeping for some time to one spot, and then extending their range in pursuit of prey, now rising quite to the surface of the water after the fry of other fishes or other surface swimming creatures; not generally gregarious except when hunting for food. The habit of the pollack and other voracious fishes of pursuing the surface fry of other kinds or perhaps of smaller individuals of their own has led to the adoption of a curious method of escape among the persecuted kinds. Mr. Peach relates the following "A small whiting was observed to have taken shelter within the hollow of a medusa (*Cyanea aurita*), a circumstance of common occurrence with very young fishes of several kinds; but in doing this the action was observed by a young pollack of about five inches in length, which immediately began an attack. The little whiting easily evaded these attacks by dodging around its friend; but the pursuer was soon joined by another of its own kind, and both of them united in the same work. For a time both of them were baffled; but an unlucky movement drove the pursued one from its shelter and a severe chase immediately took place. Several additional pollacks joined in the chase like a pack of hounds and in terror the whiting rushed to the surface. The pursuit was doubtful; but at last the hunted one became exhausted, and lay as if dead, so as to be drifted along with the tide. After a while, however, animation was recovered, and the little whiting again found refuge within the cavity of the medusa. This movement, however, was presently observed by the congregation of pollacks, which allowed it little respite. They soon drove it into open water, and after a short chase it fell a victim to their violence, and this too without their proceeding to feed on the carcase. So eager were these pollacks in the pursuit, that when stones were thrown to drive them away they showed no alarm, although at other times a single stone would have struck them with terror." The habit of young fish occasionally resorting to the protecting covering of a jelly-fish I have already alluded to; it appears that the object may be either for concealment or for the sake of feeding on such small swimming creatures as the umbrella-like disc of the medusa encloses, and its stinging thread cells have partially benumbed. I have myself witnessed small fish thus associated with medusæ in Brixham Harbour, but I did not observe any threatening enemies near; but of course a habit once engendered would show itself, from inherited instinct, even when no danger was actually imminent at the time of seeking refuge. It seems more probable that the motive of the little fish in fleeing to the gelatinous city of refuge is to be attributed rather to the desire to escape an enemy than to capture benumbed prey; but in any case the question how the fish escapes the poisonous darts of the medusa which render other creatures lifeless or inactive still remains to be answered. The malicious attacks of the marauding pollacks on the persecuted whiting which it seems was after all not required for food, is an instance of that apparently cruel and wanton instinct so often to be seen in predacious animals of various kinds, killing for the sake of killing; just as I have known an otter fish out nearly all the carp from a small pond, bring them to the bank and leave them untouched, with the exception of biting off their noses! The curious association of young fishes with *Medusæ* and *Actiniæ*, and the strange devices and doings which are sometimes seen amongst even the "mute fishes" would lead us to be cautious not to ascribe to them great want of intelligence, and absence of emotional feelings, and at the same time induce us to the belief that even some of the apparently absurd and sensational stories of Oppian (circ. A.D. 170) and other ancient writers have some substratum of fact as their basis.

*Food of.*—Young fishes of various kinds; pollack seem to be fond of feeding on their own family (*Gadidæ*); Jar mentions their systematic attacks on young cod-fish, which they surround, and gradually narrowing the circle and chasing them to the surface they pounce upon them. Sand-eels and young herrings they treat in the same manner; crustacea are also consumed, and young cuttle-fish, *squid* and *sepia*, which I believe to be a favourite and attractive food for a great number of fishes. Thompson found in the mouth a large specimen of *Sertularia falcata.*

*Spawning.*—In December, January, and February; the young, an inch in length, have been noticed by Mr. Dunn in April and May. Mode of deposition of spawn near the surface, as in *Gadus virens*, *G. merlangus*, and *G. æglefinus* (coal-fish, whiting, and haddock). Day received from Mr. Dunn specimens of young fish, of the size named above, caught at the surface of the sea on May 28th. "Over the head and neck, as seen under a microscope, were numerous small angular black spots, and elsewhere some star-shaped ones. No scales, nor even ventral fins were visible until the fish had attained four-fifths of an inch in length." The numerous angular or star-shaped spots are not peculiar to this fish, it being a marked characteristic of all young bony fishes to exhibit an extraordinary development of the pigment cells (*chromatophores* and *chromatoblasts*). Young small pollacks may be seen in the summer time near the edge of the tide on rocky ground, or in harbours. Pollack may attain a large size, nearly equal to that of the coal-fish. Thompson saw one in the Belfast market, in November, 2 ft. 9 in. in length, weighing about 12 lbs. He had also heard of individuals captured in Larne Lough, where the species is abundant, weighing 20 lbs. Couch mentions one which weighed 24 lbs.; its usual size is from 4 to 7 lbs. weight.

*Modes of capture.*—Chiefly by the hand-line (" whiffing "), towed after a boat, but some are taken in nets; very seldom in the trawl, as this fish prefers rocky parts where the trawl cannot be worked. The pollack is a greedy biter, and numbers are caught with hook and line out of boats, not far from the rocks, or in harbours which they frequent for the sake of feeding on young fry of other fishes. Pieces of herrings, pilchards, sand-launces or otter-fish, or squid are usually employed as baits. I have seen numbers caught by a bit of squid in Brixham Harbour. Cockles and whelk are sometimes used. Artificial baits are also used with success; and a gaudy artificial fly will tempt them to rise. The larger fishes are usually caught by the bottom line, with boat at anchor.

*Quality of flesh.*—Very good, and resembling the whiting, but not so firm and flaky in flesh. Said to be good all the year round, but best in autumn and winter. The best, as well in size as quality, are those which are caught at the west of the Land's End, between that point and the Scilly Islands, a district in which others of the gadoid family are also found to reach an amount of perfection that is not equalled elsewhere (Couch). They are best fried. I quite agree with Day, who says a fry of young pollack about six inches long will beat a similar dish of Cornish trout at any time.

*Commercial value.*—Seldom exposed for sale in the markets, and not generally held in that estimation which it deserves. It is seldom to be seen in Billingsgate; specimens are now and then to be seen in our midland markets, as at Birmingham and Cheltenham. It is more common in the Liverpool markets, and I have seen numbers in the Isle of Man. Thompson says that in Ireland, though the pollack is considered superior to the coal-fish, both are sold at a low cost. It is generally eaten near the coast where it is captured, and perhaps is not a fish that would keep well for any time. As a cheap source of excellent food, however, the pollack, when attainable, is a valuable fish. Colonel Montague states that it is often bought by the inexperienced as whiting in Devonshire. Pollack at whiting price, like filletted plaice at sole price, must be remunerative to the retail fish-dealers!

*Names.*—The name of pollack has been already considered. The Scottish words *Lythe*, *Laith*, *Leeat*, *Leet*, very probably refer to this fish's activity in the water. Lythe or lithe is "flexible" or "active." Low, in his "Natural History of the Orkneys," speaks of the pollack as very frolicsome fish, constantly splashing in the water. *Lithe* has as one of its meanings that of "glad." This derivation is supported by another popular name of this fish, viz. *Skeet* (*skēt*) "swift," which is our common word *skit*, "to jump about," to be *skittish*. *Skit* is a Lowland Scotch word, meaning to flounce, caper like a *skittish* horse (Jamieson), so that the names of *skeet* and *lythe* are not inappropriate to this active gadoid. Other names are whiting-pollack, and whiting-pullet.

*General description.*—Height of the body is 4¼ to 5 in the total length; snout conical, lower jaw prominent and much the longer; barbel absent, teeth of equal size, cardiform, an interspace between the first and second and second and third dorsals; anal fins separated by a short interspace. Caudal square or slightly emarginate. Head and back greenish brown or olive, becoming lighter on the sides, which are sometimes mottled with yellow; lateral line dusky curving downwards over the end of the pectoral fin. Fins dark green, edged with dark lines.

## THE HAKE (*Merluccius vulgaris*).

GENUS *Merluccius.*—Body elongated; two dorsal fins, the first short, the second long, an interspace separating the two; one anal fin; caudal distinct; ventral with seven rays, teeth in the jaws and on the vomer, rather strong, in two or more rows; scales small; barbel absent; branchiostegals seven.

Temperate seas of Europe and the coast of North America; south portion of the west coast of South America, New Zealand.

*Merluccius.*—Gesner de Aquatil, p. 84.

*Asellus primus*, Rondel.; *S. merluccius.*—Willughby, p. 174. Tab. L. M. 2, 1.

*Gadus.*—Artedi, Spec. Pisc. p. 36. No. 10; Gen. p. 22, No. 8.

*Gadus merluccius.*—Lin. Syst. Nat. i. p. 439; Lacép. ii. p. 446; Donov. Brit. Fish. ii. pl. 28.

*Merluccius vulgaris.*—Cuv. R. Anim. Jenyns' Man. p. 447; Yarrell, ii. p. 258; Parnell, F. Firth of F. p. 190; Thomps. Nat. Hist. Irel. iv. p. 184; Günther, Catal. iv. p. 344. Day, pl. iv. p. 300. pl. 85. fig. 1.

*Hake.*—Couch, iii. p. 99. pl. 148.

*Geographical distribution.* — Coasts of Europe, from Scandinavia to Madeira, the Mediterranean and the Adriatic; common round the British coasts, but more abundant in the south and south-west of England and Ireland; generally rare in Scotland; occurring in the Orkney and Shetland Isles; occasionally found on the Dogger Bank, and known on the Yorkshire coast; numerous in the autumn and winter off the coasts of Devonshire and Cornwall; in Ireland most common on the southern coast; once so abundant in the Bay of Galway that this bay is called in some ancient maps the "Bay of Hakes," (Cuvier, Pennant, Yarrell); not often exposed for sale in Belfast market. In Donegal Bay the hake fishery begins in September; a considerable number are brought during the autumn and winter to Brixham and Plymouth.

*General habits.*—Assemble in large shoals when in pursuit of their prey, such as herrings, pilchards, and other fishes; a bold and very rapacious fish, feeding generally at night and keeping near the bottom during the day. Robs the nets of other fish, and is frequently caught entangled by their teeth; frequenting bays in the summer and deep water in the cold winters. Thompson relates that a large hake that had been left in shallow water by the receding tide, looking apparently dead, seized the thumb of a man, who incautiously took hold of it, with such eagerness, that in order to release himself, he was obliged to bring away three of its formidable teeth deeply imbedded in his flesh. Their assembling together is influenced by their predacious habits, for like a pack of wolves, they hunt their prey; probably also by the fear of large predacious fishes of other kinds or of porpoises. Some fish, when attacked by an enemy, unite their ranks and press closely all round him, and so molest and throng him, that he is compelled to retire, as has been noticed in the case of the hake and pilchards. [see pilchard].

*Food of.*—Various other fishes, as herrings, pilchards, mackerel, anchovies, sprats, etc. To what extent the hake feeds on crustacea or molluscs, or other marine animals is not known; probably fish are the chief diet. Swift, strong, and voracious, with the body formed for rapid motion, the hake is able to capture very active prey. Its presence in the neighbourhood of shoals of pilchards or herrings favours the idea that fish is the principal food. The examination of the stomachs of many of these kinds of fishes which are taken with a baited hook often reveals a complete absence of any food within them; this is owing to the fact that a hooked fish will frequently disgorge, perhaps from terror, the contents of the stomach. It is common to see in a number of large hooked fish even a portion of the stomach itself partially protruded, especially when such fish have been hooked in great depths. Moreover, the presence of a shoal of hakes is often synchronous with that of a shoal of other fish, as pilchards; and the appearance of the latter in large numbers in a certain locality is a fair index to the probability of a shoal of hake being not far off. As the herrings and pilchards are constantly on the move, so is the hake who pursues them; and as the occurrence of shoals of pilchards and herrings, or mackerel is very uncertain at particular places, so is the occurrence of the hake uncertain. The chief motive which prompts most sea fishes to change their localities, is the desire for and search after appropriate food. We are accustomed to call such appearances or disappearances "capricious;" but probably there is no caprice in the matter at all. When food fails in abundance in certain localities then the fish are prompted by hunger to seek "fresh fields and pastures new." I do not say that this is in all cases the unvarying rule, and that it will account for all the phenomena connected with migrations and destination; but it appears to me to be the reasonable explanation of the matter in most cases. A writer in 'Land and Water' (Sept. 1866) mentions a belief that hake feed on dead bodies occasionally. This may or may not be true. It is possible that a hungry hake, in the absence of more lively bait, may have recourse to an occasional repast of that kind.

*Spawning.*—January, February, March and April appear to be the general months, but the spawning time may be delayed by cold weather. I have seen many young "baby hakes," from nine to twelve inches long, at Brixham and Plymouth in October, which I take to be the produce of the February spawning. The mode of deposition of the spawn has not been observed. The hake attains to the length of 4 feet, and to a weight of 24 pounds.

*Modes of capture.*—A considerable number, especially of small fish, are taken by the trawl; but line-fishing catches a greater number. Devonshire and Cornwall abound most in hake. Bellamy states that 60,000 have been caught by trawlers and brought into Plymouth in the months of December and January, and Couch mentions the enormous quantity of 40,000 having been landed in Mount's Bay in one day; on another occasion 1100 were taken by one boat in two nights. The hooks are baited with a piece of herring, pilchard, squid, or even with a slice of its own kind. The pilchard season, October to December, is the best time for catching hake, as this fish is very fond of pilchards, and follows them as already mentioned. Where herring shoals occur, but no pilchards, then the hake will be found among them, and it probably has no predilection for a pilchard; in the nets set for this latter fish, on the south-west coast of England, great quantities of hake are sometimes captured.

*Quality of flesh.*—Not generally held in much estimation; but considered very good food by many persons. A writer in 'Land and Water' says, that, "the hake is sent to table in a variety of ways, and is excellent in all. He may be broiled, boiled, cut up, dried and salted, and in none of these forms comes amiss. His flavour partakes of the delicacy of the whiting, with more flakiness and consistence." The hake is thought very good by the people at Brixham. I cannot myself speak highly of it.

*Commercial value.*—Of more importance than formerly, owing to the high price of fish in general. The greater proportion are salted, and thus prepared are extensively used by the fishermen. The wholesale price for a *burn*, (i.e. a "burden for one person") of twenty-one fish, in West Cornwall, is 15*s.* to 20*s.* and at the retail price 1*s.* to 1*s.* 6*d.* each fish according to size. Formerly a high wholesale price was 3*s.* 6*d.* Considerable numbers of hake are brought to the dock-market at Grimsby. The wholesale price there varies from 20*s.* to 100*s.* per score, according to size and quality, or as much as 5*s.* a piece for large fish. Salted hake used to be called "poor John" in some parts of England. Large quantities used to be salted and sent off to Bilboa in Spain (Pennant). In Pennant's time the hake was considered a very coarse fish "and was submitted to table either fresh or salted."

*Names.*—The hake has been supposed to be the fish known to the Greeks as ὄνος and to the Latins as *Asellus.* After going carefully through the whole question, it is perfectly certain that the hake does not in the least degree answer to the requirements of the *ὄνος* and *Asellus* of the classical authors The *onos* is represented as hiding itself in the sand and employing its oral appendages as a means of deluding other fishes, like the angler; as a solitary fish, as a sluggard, *ὄνων νωθρὸν γένος* (Oppian, Hal.) Varro says that *Asellus* (= *ὄνος*) is so called from the ass-like colour of the skin; and this to a certain extent is the only particular which might suit the hake. The *ὄνος* may possibly be, as Badham conceives, the *Phycis Mediterranea*; but it clearly cannot be the hake.

The word *hake* is probably to be traced to the Icelandic *haka* the *chin;* the name having reference to the lower jaw which is longer than the upper. The *merlus* of the French is from the Latin *merluccius*, "sea-pike" or "sea-luce," a very good name for the rapacious fish. The Welsh name of *Cegddu*, literally "black-mouth," expresses a fact in the fish.

*General description.*—Height of the body 6¼ to 8 in the total length; head flattened above; under-jaw longer than upper; no barbel, teeth sharp, long and strong; inside of the mouth and gill-covers black. First dorsal fin separated from the second by an interspace, the second dorsal and the anal fin are higher posterially than anterially. Ventral a part of the pectoral. Colour, greyish or dusky brown, lighter beneath; fins dusky and pale brown; lateral line nearly straight.

## THE LING (*Molva vulgaris*).

GENUS *Molva*.—Body elongated, nearly cylindrical, and eel-like, covered with small scales; chin with a barbel. Two dorsal fins, the first separated from the second by a small interspace, anal and second dorsal distinct from caudal; ventral narrow with six rays. Teeth in the jaws and on the vomer in a cardiform band; absent from the palatines and tongue; some large teeth in the lower jaw and on the vomer; branchiostegals seven, pseudo-branchiæ absent. Native fishes of the temperate waters of the Northern Hemisphere.

*Clarias marina.*—Belon, de Aquatil. p. 131.

*Asellus longus*; Ling, Anglis dictus— Willughby, p. 175. Tab. L. M. 2, No. 2.

*Gadus.*—Artedi, Spec. Pisc. p. 36, No. 9; Gen. p. 22, No. 9.

*Gadus Molva.*—Lin. Syst. Nat. i. p. 439; Lacép. ii. p. 432; Donovan, Brit. Fish. iv. pl. 102;

*Lota Molva.*—Jenyns' Manual, p. 448; Yarrell, ii. p. 264; Parnell, F. Firth of Forth, p. 192; Thompson, Nat. H. Irel. iv. p. 185.

*Molva vulgaris.*—Flem. Brit. Anim. p. 192; Günther, Catal. iv. p. 361; Day pt. iv. p. 305. Pl. 86;

*Ling.*—Pennant, Brit. Zool. iii. p. 262; Couch, iii. p. 89, pl. 145.

*Geographical distribution.*—From the northern coasts of Europe to the western part of the Mediterranean; abundant along the coasts of north Europe to Iceland, in the North Sea and off Norway; absent from the Baltic; very common off the Orkneys, St. Andrews, and in the Firth of Forth. Abundant off Yorkshire and Norfolk, but not of large size; frequent in Devonshire, and common in Cornwall and the Scilly Islands. Found all round the Irish coasts.

*General habits.*—Frequents the rocky borders of the wide valleys of the sea, preferring deep water and feeding generally near the ground, a bold, greedy, and voracious fish, very tenacious of life; approaching the coasts at spawning time. Like the cod-fish, the ling will swallow occasionally almost any substance it meets with. The late Mr. F. Buckland had, in his museum at South Kensington, a pewter flask containing two glasses of ardent spirit, which had been taken from the stomach of a ling, caught off Brandon Head, Co. Kerry, in February, 1849. Similar instances of this fish swallowing foreign substances are recorded. In one stomach were found several bits of parchment and sealing wax —"inducing the supposition that it had swallowed one of those mournful messages of shipwreck, which are far too common" (Day).

*Food of.*—Almost any living thing not too large for its mouth and gullet, with the exception of crustacea, which, curiously enough, this fish does not seem to care for; the stomachs of fish caught where crabs and lobsters were known to abound, showing no evidence of this food; plaice, dabs, flounders, skulpins (*Callionymus lyra*), called by the Torbay fishermen "Millers' thumbs," and even dog-fish have been found in lings' stomachs. I was told by a smack-owner at Brixham, that he once took out of a ling's stomach a small sucking-pig! A sow, doubtless, had farrowed on board some vessel, a little pig died and had been thrown overboard, and a ling, somewhere near, had met with it, and consigned it to its living tomb.

*Spawning.*—April, May, and June. The mode of deposition of the spawn is not certainly known. Pennant states that in the Yorkshire seas the ling spawns in June, and "deposits its eggs in the soft oozy ground off the mouth of the Tees, at which time the males separate from the females and resort to some rocky ground near Flamborough Head, where the fishermen take great numbers, without ever finding any of the female or roed fish among them." This statement of Pennant (Brit. Zool. iii. 262, ed. 1812), must not be received without absolute proof. Several of the *gadidæ* are known to spawn near the surface, and in the allied genus to *Molva*, viz., *Motella*, the *M. argenteola* is a surface spawner. Still we may meet with distinctions in this respect, not only among genera, but even among different species. The herring is known to be a ground-spawner; the pilchard is probably a surface-spawner, both belonging to the genus *Clupea*.

The ling is a prolific spawner, the roe of a large one has been known to weigh 11 pounds. Young specimens, about a foot in length, are described by Thompson as being prettily coloured. In one he examined, he states that the colour of back and sides was yellowish olive, handsomely broken and divided throughout into patterns of lines of pale lilac, the ventral fins were white, with a delicate lilac hue. The usual length of the ling is from three to four feet. Pennant mentions one of seven feet; the largest native specimen of which Thompson had a record, weighed 59 pounds, and was captured near Carrickfergus. Thompson also speaks of one caught in Belfast Bay which was 5 feet long. The person who caught it described it as "having evinced great ferocity when brought into the boat."

*Modes of capture.*—By hand lines and long lines; the season of best catches varies on different parts of the coast. In the west of England it is in January and February; in Scotland from the 20th of May to the 12th of August, the well-known date of the commencement of grouse-shooting. In the north of Ireland, it is in March, the fish not spawning there till the end of May. Decked and open boats are used. The hooks are baited with a piece of herring, plaice, flounder, conger or squid, all of which should be used when e fresh. In Galway, where ling is taken in large quantities, 15 to 20 dozen being caught in a day on a long line, the ling fishermen generally remain out a week from home, and come in every night to a harbour in Baffin Islands. Sharks and dog-fish frequently rob the lines of the captured ling, especially in the Orkneys and the north of Scotland.

*Quality of flesh.*—It is not generally held in high esteem in a fresh state, but is extensively consumed by the fishermen and by the poorer classes. The flesh is void of that firmness and flakiness that belong to several other species of the cod-fish family, and the flavour cannot be highly recommended. But "de gustibus non est disputandum," for Rowell says, that "when boiled it is much like cod, but firmer and whiter and has a fine flavour, but to make a dinner of it, it should be baked, well-seasoned with nutmeg, salt and pepper, and a lump of the liver cooked with it. When thus prepared it makes a dinner one can eat with great relish, and feel very satisfied after it." (Day, iv. p. 307). Buckland also thought highly of ling. He says: "It is surprising that it is so little eaten by Englishmen, for in it cheapness is really combined with goodness." The roe-lobes when about half developed are thought a delicious dish fried or roasted. The greater proportion of ling is salted, both for home and export consumption. It is considered to be in best season from February to the end of May. Young fish are decidedly preferable to large ones; when boiled ling is insipid, it is better fried or baked. Some people think it is very good in a pie. It is not to be despised when stewed, but then much depends on the richness of the gravy, and the discriminate use of tasty sauces. The young fish, which in Yorkshire are called *drizzles*, are largely consumed there, and are thought excellent. Doubtless the ling forms a cheap and nourishing diet, and on this account, and from its great abundance, it must be deemed a very valuable article of fish-diet.

*Commercial value.*—When salted, ling is a very considerable article of commerce, especially in Orkney and Shetland, where this fish abounds. It is not possible to speak in definite terms of the quantity of ling taken in Scotland, because the reports of the Commissioners of the Fishery Board include in their accounts cod and hake as well as ling. The total quantity of cod, ling, and hake taken during the year ending December, 1880, was 163,539¾ cwts., of which 155,745¼ cwts. were cured dry, and 7,794½ cwts. were cured in pickle, and the total quantity exported was 79,946 cwts.; for the year ending December, 31st, 1881, there was a falling off, as shown by the following figures. Total captured, 119,589 cwts., of which 115,513½ cwts. were dry-cured, and 4075½ cwts. pickled; 61,426 cwts. being exported, Spain and Italy take the principal proportion of these cured fish. The wholesale price of live ling at Grimsby is from 40*s.* to 180*s.* per score, according to size and quality. The ling is very little seen in London, being confined chiefly to such places as the New Cut, Lambeth, where it is sold at 3*d.* per pound to the poor of the neighbourhood. Ling is prepared like cod; the head is cut off, the body then split, salted in brine and dried, when it is ready for transmission. The liver is full of oil, and is used for lamps and other purposes. Perhaps it may be as beneficial as the liver of cod medicinally; perhaps ling-liver oil *is* used in the preparation of cod-liver oil. At any rate, it has been used in severe cases of rheumatism; the exudation of the skin of those who had taken it is said to have exhaled a *lingy* odour. Coarse isinglass is made from the ling's air-bladder, or "sounds" as they are popularly called, similar to that obtained from the cod-fish. The fish are good throughout the year, except for a month or two just after spawning, so that they afford wholesome food from August to May, speaking generally, though in Shetland the chief period for capture, as already mentioned, is from May to August.

*Names.—Ling* beyond all doubt denotes *long*, and refers to the great length of this Gadoid. It is so named in several European languages: the Dutch *leng;* the Icelandic *langa*, a ling, from *langr*, "long;" the Norwegian *langa*, *longa;* the Swedish *långa;* the German *länge*—also called *läng-fisch*—"long fish." Satchell, in his Provisional Index to a Glossary of Fish Names, gives the following: *drizzle, ling-grissle, olic, spotted-ling, nathe, white-ling. Drizzle* is explained in Halliwell (2) "as a very small salt ling."

*General description.*—Height of the body, 7 to 8 in the total length; lower jaw shorter than the upper, with a single barbel longer than the eye; a short barbel near each nostril; teeth in the upper jaw small and numerous, in the lower jaw larger and stronger; a semi-circular band on the vomer, with a few larger ones interspersed; very small interspace between the first and second dorsal, pectoral about half as long as the head; ventral jugular, anal fin resembling the second dorsal, and, like it, distinct from the caudal, which is rounded; lateral line nearly straight; scales small and adhering to the skin. Colour: the back and sides grey, lighter beneath; dorsal, anal and caudal edged with white. The pretty colour of the young lings has been already referred to.

## THE TORSK (*Brosmius brosme*).

GENUS *Brosmius*. — Body somewhat elongated and covered with small scales; a single dorsal fin extending from a line about level with the origin of the pectoral down the whole back; anal much shorter; both dorsal and ana fins are distinct from the caudal, which is rounded branchiostegals seven; ventrals narrow, with five rays; teeth cardiform, and in the upper jaw in a narrow band; present on the vomer and on the palatine bones; pseudobranchiæ absent; a barbel at the chin.

From the Polar Seas, along the northern coasts of Europe as far as Yorkshire; coasts of the United States as far as Cape Cod.

*Brosme.*—Ström. Söndm. i. p. 272, t. i. fig. 19; Pontopp. Norg. Nat. Hist. ii. p. 207.

*Torsk.*—Pennant, Brit. Zool. iii. p. 269, pl. xxxvii.

*Torsk-fish.*—Low, Faun. Orcad. p. 200.

*Gadus brosme.*—Fabric. Faun. Grœnl. p. 149; Lacép. ii. p. 450; Donovan. Brit. Fish. iii. pl. lxx; Faber, Fische Islan. p. 84.

*Brosmius vulgaris.*—Flem. Brit. Anim. p. 194; Jenyns' Manual, p. 452; Yarrell, ii. p. 285; Nilss. Skan. Faun. iv. p. 597; Parnell, Fish. Firth of Forth, p. 197; Thompson, Nat. H. Irel. iv. p. 186.

*Brosmius brosme.*—Günther. Catal. iv. p. 369: Day, pt. iv. p. 323, pl. xc. fig. 2.

*Torsk.*—Couch, iii. p. 96, pl. 147.

*Geographical distribution.*—A decidedly northern fish, extending from about 73° to 53° N. Lat., but rare so far south. It occurs in Spitzbergen abundantly, also on the north coast of Norway, among the Faroes and on the south and west of Iceland. A considerable number of torsk are brought in to Grimsby during the season every year by the North Sea fishermen ; it is occasionally taken off the coast of Yorkshire, where it appears to have reached the *ultima Thule* of its southern wanderings. It is occasionally caught in the Firth of Forth, while at Shetland it swarms, and is as common as the ling ; is not so common in the Orkneys ; has been recorded from Wick, where it is taken about fifty miles to the north-east, in about 50 fathoms of water, at a place called Skate Hole, from the abundance of these fish (Day). It has been taken at Whitby (1860), and is said to be frequently caught in the deep water off the Yorkshire coast. Its visits so far south are probably exceptional. Couch says there is no record of the fish being met with in England.

*General habits.*—Lives in deep water, and the adult fish are seldom met with excepting at great depths, from 60 to 100 fathoms. The young approach the land in shoals early in the year, and leave late in the summer. It prefers a rocky bottom where there is an abundance of seaweed during the spawning time. A writer in *Land and Water* (May 7th, 1881) states that from the middle to the end of April, 1881, large shoals of these fishes were found following in the track of the herrings during the spring herring fishery off Sweden. According to Faber (*Naturgeschichte der Fische Islands*, Francf. 1829), the torsk is often thrown up dead in large numbers on the coasts of the Faroe Islands and the south coast of Iceland after storms. The same authority states that the larger kind of cod pursue it, and that it is much troubled with a parasitic worm which infests its skin and produces tumours.

*Food of.*—The torsk, living at a great depth, like other fishes of similar habits, seldom shows signs of any food in the stomach. The contents are vomited when the fish is hooked, and the empty stomach has given rise to the belief that it feeds only on the pieces of seaweed. But an empty stomach is no proof of abstinence from food, not only in deep-water fishes, but in other kinds. It is always necessary in examination to pay attention to the contents of the intestines, some portion of which generally contains the remains of food, the nature of which can be more or less satisfactorily ascertained by the use of the lens and microscope. The food of this fish is much the same as that of the cod and ling. "Among several examined, in the stomach of one was found a good-sized haddock, two small flounders, a buckie with a hermit crab inside it, and small corallines, while in some of the others were crustaceans and small fish" (Day). In the stomach of another was found what appeared to be roe, which was "mixed with a dirty bluish thick liquid, and a large fish-hook of 3½ in. in length."

*Spawning.*—It breeds in April and May among fuci or other seaweeds, according to Faber; but this statement still awaits corroboration. Its average length is about 18 inches, but it attains to a much greater size. Low mentions one 42 inches in length; and on the south coast of the Island of Fühnen, in 1880, one weighing 42 lb., whose roe weighed 7 lb., was captured.

*Modes of capture.*—By long-lines and hand-lines, similar to cod and ling; more generally by hand-lines with small hooks. So abundant were the torsk said to be at certain times in the fiords of the Island of Spitzbergen, that they could be captured with hand-nets.

*Quality of flesh.*—According to Faber, hard but well-flavoured. Olsen says the flesh when eaten fresh is not good, and is best when dried. Low says it is one of the best of cured fish, swells in boiling, and is flaky ; when eaten fresh he confesses it is rather tough, and that on this account people prefer it salted.

*Commercial value.*—Seldom if ever seen in any of the English markets excepting at Grimsby, to which port it is brought by the North Sea fishermen. In the Shetlands torsk forms a considerable article in the fishing trade of the inhabitants. Formerly torsk-fishing in Norway was not much pursued, and formed no branch of merchandise. What was taken was treated as *stockfish*, and eaten by the population. Owing, however, to the investigations and discoveries of Sars, the Norway torsk fishery is assuming some importance. There can be no doubt that this fish properly cured forms wholesome food. Its distant northern habits, however, have hitherto precluded its being brought forward as a commercial fish of importance.

*Names.*—The name of Brosme, whence the Latin generic name of *Brosmius*, was first used by Ström in his ' Physical and Economic Description of the Bailiwick of Söndmör, Bergen, Denmark' (*Physisk og œkonononomisk Beskrivelse over Fögderiet Söndmör*, i. p. 272. Soröe, 1762), and by Pontoppidan, ' History of Norway ' (ii. p. 207). The name of *torsk* (or tusk) is Danish, and is used for a cod or haddock as well as for the fish under consideration. *Brismak* is another name of this fish, and is used in Shetland. *Klip-fisk* is Danish, and is used for the torsk when dried, " haberdine," stock-fish. In Massachusetts it is called *cusk.*

*General description.*—Head small in proportion to the fish, the chin furnished with a barbel ; height of body, about 8 in the total length ; upper jaw somewhat the longer ;

teeth cardiform, with an inner row in the lower jaw the larger; palatine and vomerine teeth mixed with larger ones; absent from the tongue. Dorsal fin single and thick, commencing above the root of the pectoral, continuous to the root of the caudal, where it is distinct; anal fin distinct from the caudal, which is rounded. Ventrals fleshy and broad, ending in joints. Lateral line not distinct. Colour: head and upper part of the body dusky grey tinged with yellow, lighter on the sides and beneath. All the fins except the ventral have a light whitish border; a dark base on the caudal, dorsal and anal.

## FAMILY *Pleuronectidæ.*

Body strongly compressed, flat, with one side coloured, the other white, or occasionally spotted; the coloured side always uppermost; the eyes, except in very young individuals, both on the coloured side, and sometimes rudimentary. Bones of the head unsymmetrical, not equally developed; dorsal and anal fins long and undivided; pectorals present, rudimentary or absent; scales of moderate size, small or absent; lateral line on the coloured side, single, double, triple or absent, curved or straight. Air-bladder absent; gills four; branchiostegals, six to eight; pseudo-branchiæ well developed. Carnivorous fishes; inhabiting the sandy or muddy bottoms of the seas of all the regions; many ascending rivers for great distances; seldom inhabiting very great depths, or frequenting rocky coasts. Some forms can be readily acclimatised in fresh water. The Pleuronectoids may be divided into two great divisions.

A. *The jaws and teeth nearly equal on both sides, containing the following British genera, with their chief characteristic distinctions.*

1. *Hippoglossus.*—Eyes on the right side; teeth of the upper jaw in two series; dorsal fin commences above the eye.

2. *Hippoglossoides.*—Eyes on the right side; teeth small and in a single series; dorsal fin commences above the eye.

3. *Rhombus.*—Eyes on the left side; teeth of the jaws forming a band, teeth on vomer; the dorsal fin commences at a point between the eye and the snout.

4. *Zeugopterus*, Gottsche = *Phrynorhombus*, Günther.—Eyes on the left side; teeth of the jaws in a band; vomerine teeth absent; the dorsal fin before the eyes.

5. *Arnoglossus.*—Eyes on the left side; teeth small in the jaws and generally in one series; dorsal commences near the snout; scales deciduous.

B. *Jaws and teeth unequally developed; more on the blind side than on the coloured.*

6. *Pleuronectes.*—Eyes on the right side; upper eye in a line behind the lower, or even with it, but not in advance of it; teeth of moderate size; dorsal fin commences above the upper eye, but not in advance of it; pectoral fins both present.

7. *Solea.*—Eyes on the right side; teeth small only on the blind side; scales ctenoid; upper eye in advance of the lower; the dorsal fin commences above the upper eye. Pectorals developed, rudimentary or absent.

## THE HOLIBUT (*Hippoglossus vulgaris*).

GENUS *Hippoglossus.*—Eyes on the right side; head small, compared with the size of the fish; mouth wide; teeth in two rows on the upper jaw, the outer teeth being conical; in the lower jaw conical and widely set; lingual, palatine and vomerine teeth absent; dorsal fin commences above the eye; the rays of the dorsal and fin rays, except the last few, simple; scales very small, cycloid. Lateral line nearly straight or curved anteriorly; branchiostegals seven.

*Hippoglossus.*—Rondelet, xi. c. 16, p. 325; Willughby, p. 99, tab. F, M, 6; Gesner, pp. 669, 787.

*Pleuronectes.*—Artedi, Spec. Pisc. p. 31, No. 3; Gen. p. 17, No. 3.

*Helleflynder.*—Pontop. Norg. Nat. Hist. ii. p. 220; Ström. Sönd. i. p. 300.

*Pleuronectes hippoglossus.*—Lin. Syst. Nat. i. p. 456; Lacép. iv. p. 601; Donov. Brit. F. iv. pl. 75.

*Hippoglossus vulgaris.*—Flem. Brit. Anim. p. 199; Jenyns' Manual, p. 460; Yarrell, ii. p. 321; Parnell, Fish. of F. of Forth, p. 212; Day, pt. v. p. 5, pl. 94; Günther, Catal. iv. p. 403; Study of Fishes, p. 555.

*Holibut flounder.*—Pennant, Brit. Zool. iii. p. 302.

*Holibut.*—Couch, iii. p. 149, pl. 159.

*Geographical distribution.*—North Atlantic, from the coasts of Spitzbergen to the shores of the British and French coasts; well known on the coasts of Norway, Iceland, and Greenland; abundant off the Orkneys and Shetland; common in the North Sea; great numbers are annually brought in by the cod vessels to the Grimsby

Dock Market, where they meet with a ready sale. Resident off the Yorkshire coast, but said to be not so numerous now as 30 or 40 years ago. Occasionally taken at Yarmouth and on the eastern shores, becoming rarer southwards, though large specimens are sometimes captured off the Devonshire and Cornwall coasts; has been taken of large size in the Isle of Man. Frequent along the east coast of Scotland; found in the Moray Firth, Banff, Aberdeen, and St. Andrews. According to Thompson, the holibut is occasionally taken on all parts of the coast, chiefly on those of Down and Antrim and Belfast Bay, where they occur from December to March inclusive. The holibut is found on the coasts of Kamtchatka and California, on extensive deep-sea sand-banks, from 50 to 100 fathoms.

*General habits.*—An inhabitant of deep waters, feeding generally, like the cod, near the bottom. Bloch states that they lie at the bottom in rows with open mouths, waiting for the approach of crabs or fishes that may come within reach, and if unsuccessful in their object, that they will occasionally make a formidable attack on the tail of their nearest neighbour. In reference to this assertion, Couch remarks that it may be able to account for the frequent injury which the captured holibut exhibits on its tail, which is often much lacerated and sometimes entirely lost. The lacerated or tailless holibuts, however, do not generally owe their losses to an attacking enemy of any kind. I have seen numbers of these semi-mutilated fishes at Grimsby, and on my inquiring the cause I was told that it was owing to the violent exertions of the fish to rid themselves of the cord which the fishermen tie round the tail, whereby to suspend them. When hooked or speared, a large holibut fights vigorously to escape, and requires great tact and judgment on the part of the fisherman to secure it. Thompson, however, says that the Irish fishermen consider it to be a simple fish, easily killed, and that they never lose one in consequence of its weight (p. 200).

*Food of.*—Other fishes; crabs and other crustacea; Ophiuridæ (*Ophiocoma rosea*), molluscs. In a fish weighing 120 pounds, Thompson found the remains of a ray, the tail of which was about a foot in length, "the position of the victim showing that it had been swallowed head foremost." Holibut are perhaps the most voracious of all the *Pleuronectidæ*, and, like some of the Gadoids (cod-fish family), are sometimes indiscriminate in the objects they swallow. Pennant states that two instances occurred in one year of their swallowing the lead weight at the end of a line, with which the seamen were sounding the bottom from on board a ship; one off Flamborough Head, the other going into Tinmouth Haven; the latter was taken, the other disengaged itself. In the stomachs which I have examined I found crushed molluscs, such as razor-shells (*Solen*).

*Spawning.*—In the spring. Mode of the deposition of the spawn has not been ascertained; the roe is said by Buckland (Familiar Hist. of Brit. Fish. p. 162) to be of a pale red colour, and the ova very numerous. The holibut is the largest of the family, and may attain to the weight of several hundredweights. Olafsen, who wrote on Iceland, (Reyse igiennem Island, etc. Soröe, 1772, 2 vols. 4to), mentions a holibut nearly 20 feet in length, so that in some rare instances, as Couch observes, it seems scarcely an exaggeration in Lacépède to compare a holibut to a whale. Pennant mentions one caught in the Menai Straits weighing 300 pounds, measuring 7 feet 6 inches in length, by 3 feet 6 inches deep. Specimens of 100 pounds in weight are frequent. The largest I ever saw was at Grimsby; it weighed about 119 pounds. Large fish are caught on the Newfoundland bank, where it appears to meet with very abundant food.

*Modes of capture.*—By hook and line; frequently on the cod lines. They are also taken by the trawl. The baits used are a piece of fish, or whelk or squid; any bait which is used for the cod or turbot will answer. Couch states that holibut are fond of congregating, and that when lying in shallow water, basking in the sun, the fishermen sometimes attempt to spear them, but that they are obliged to be very careful, as the fish are powerful, and the boats are in danger of being upset. When the fish is pierced with the spear, the fisherman raises it very slowly, and so soon as it is brought within reach a club is used. Mr. Lord gives an interesting account of holibut spearing as practised by the Indians of Port Rupert, in North America, in his 'Naturalist in British Columbia.'

*Quality of flesh.*—Firm, but said to be somewhat dry in the large examples; fish of 3 to 4 feet in length are, however, very good food. The head and the parts about the fins are represented as being the "tit-bits." Some people say that holibut should not be boiled, and that it is much better baked or stewed. I think boiled holibut excellent. The flesh is delicate and tasty. Mr. Rowell, in *Land and Water*, gives the following receipt, and thus expresses his opinion of the fish. "Get a piece of holibut from a small one, season it with nutmeg, pepper and salt, and bake it in the oven, and I know nothing so fine; no fish—turbot, sole or salmon—can excel it. It does not do to boil, it is too soft, I think, and it is too thick to fry, and it does not do to slice it; but cut a piece, 3 or 4 pounds or more and bake it; it makes a most delicious fish dinner." Curried slices of holibut are much recommended by some persons. Rondelet (circ. 1550) speaks of this fish as "one of hard but pleasant flesh, very similar to that of the turbot."

*Commercial value.*—Of much more importance now than formerly; frequent in the markets of the north of England, especially at Grimsby, where it meets with a ready sale, the price varying from 7*s.* to 18*s.* per stone; the ordinary selling price being about from 8*s.* to 12*s.* per stone. Mr. Rowell states that holibut is greatly esteemed at Newcastle, and, as a test, notes that cod is retailed at 4*d.*, ling at 5*d.* or 6*d.*, and holibut at 10*d.* or 1*s.* per pound, which prices show the places respectively they hold in local estimation. It is frequently seen in the London markets; but it is not held in the estimation which it deserves. The Jews are said to be very fond of holibut, but they must have the whole fish with the head and gills intact. So little was once thought of its flesh that it has disparagingly been termed "the workhouse turbot." It is largely consumed in Greenland, Norway and Iceland, where it is cut into slips and dried in the sun, or salted and put into barrels. Our early English ancestors appear not to have despised holibut, which is a dish not unfrequently mentioned in John Russell's 'Boke of Nurture,' and in the 'Boke of Kervynge, emprynted by Wynkyn de Worde' in 1413 A.D.

*Names.*—*Holibut*, also written *halibut*, is a compound word, consisting of the Middle English *hali*="holy," "sacra" and *butte*, "a plaice or flounder," so called because excellent food for holidays. This is evident from similar names in the cognate languages. Dutch, *heilbot*, *heilig*, "holy," and *bot*, "a plaice;" Swedish, *helgflundra*, "holy flounder;" Danish, *helle-flynder.* In a very old quaint book in black letter, without date, by Laurens Andrewe, 'Extracts about Fish,' &c., *botte* is described as "a flounder of the fresshe water, and they swimme on the flatte of their body, and they have finnes rounde about theyr body, and with a sothern wynde they waxe fatte and they have rede spottis." ('Early English Meals and Manners,' Early Engl. Text. Soc. 1868, p. 115.) Young turbots were also called *bults.* The name of the genus *Hippoglossus* was first given by Rondeletius to denote the halibut; the ordinary Greek name for a "sole" was *Buglossus* (βούγλωσσις), and as the holibut was, as it were, a mighty fish of the same family as the sole, the name of *Hippoglossus* was given to express it, the Greek word ἵππος in composition denoting anything large, like our words "horse-chestnut," "horse-leech," &c. So Gesner and Willughby explain: *hippoglossus* id est Buglossus maximus in Oceano. *Turbot* is sometimes used in the Moray Firth for the holibut, and has continued since the days of Willughby, who gives as a synonym for *holibut* of the Southern Englanders *turbot* of the Northern people. The French name *Le Flétan* is conjecturally explained (in Gesner, p. 669): "Quod fluitando natet." English provincial names are *Lady Fluke*, and *turbot flook; bradan leathan*, "flat salmon," is said to be used in the Moray Firth; at Aberdeen large fish are *turbots*, very old black ones are "*blacksmiths*," and young ones are *birdies.*

*General description.*—Height of the body about one third of the total length; lower jaw slightly prominent; head small; mouth wide; teeth conical, pointed; in the lower jaw the teeth are widely placed on each side; interorbital space flat and naked. Lateral line arching over the pectoral fin; the dorsal fin commences above the eye, ascends to about the middle of the body, where it is broadest, then descends towards the caudal, gradually narrowing; caudal emarginate, with a wide interspace, between it and the dorsal and anal fins; the rays are unbranched, except a few of the last. No spine before the anal, scales small, not ciliated, dorsal and anal fins destitute of scales; the interorbital space is also naked; gill-rakers short, compressed, widely set, not half as long as the eye. Colour: light brown, dusky brown, yellowish brown or olive marbled with darker blotches; under or blind side white. Body more elongated than other Pleuronectidæ, except the sole, whose proportional breadth and length are about the same as in the holibut.

### THE TURBOT (*Rhombus maximus*).

GENUS *Rhombus.*—Eyes on the left side; cleft of the mouth wide; a narrow band of teeth in the jaws, without canines; teeth present on the vomer, absent from the palatine bones; dorsal fin commences before the eye, on the snout (behind the eye in young fish); dorsal and anal fin rays mostly branched; gill membranes scarcely united at the throat; scales small or absent; gill-rakers lanceolate and well developed; branchiostegals seven.

(?) *Ψῆττα, ψῆσσα.*—Aristot. iv. 11; v. 9; ix. 37; Ælian, xiv. 3; Aristoph. Lysist. 115, 131; Plat. Symp. 191 D.

*Ῥόμβος.*—Athenæus, vii. 330 B.

*Rhombus.*—Pliny, ix. 20, 36, 67; Hor. Sat. i. 2, 116; Juv. iv. 39; Mart. ep. xiii. 81; Ovid, Hal. 125.

*Rhombus aculeatus.*—Rondelet, xi. c. 2. p. 310; Gesner, De Aquatil. p. 661, 670; Willughby, p. 93, tab. F, 8, fig. 3.

*Pleuronectes.*—Artedi, Spec. Pisc. p. 32, 6; Gen. p. 18, 9.

*Pleuronectes maximus.*—Lin. Sys. Nat. i. p. 459; Donov. Brit. Fish. ii. pl. 46; Flem. Brit. Anim. p. 126; Jenyns' Man. p. 461; Thompson, Nat. H. Irel. iv. p. 200.

*Rhombus maximus.*—Willughby, p. 94, tab. F, 2; Yarrell, ii. p. 324; Parnell, F. Firth F. p. 42; Günther, Catal. iv. p. 407; Day, pt. iv. p. 11, pl. 96.

*Turbot flounder.*—Pennant, Brit. Zool. iii. p. 315.

*Turbot.*—Couch, iii. p. 155, pl. 161.

*Geographical distribution.*—The coasts of Europe, from the Scandinavian Seas (Lat. 62°), around the British coasts, and those of France and Portugal, to the Mediterranean and Adriatic. In the Baltic, up to about the 61st or 62nd degree of latitude; occurring in the Orkneys and Shetland; common at St. Andrews; plentiful in the North Sea, and resident off the Yorkshire coast, Northumberland and Berwickshire. It appears to grow to a large size as it descends southwards, very fine ones being taken near Margate, Dover, &c., in certain times of the year. The Devonshire and Cornwall turbot are considered very excellent fish, and connoisseurs pretend they can tell a southern fish by the superiority of its flavour. It is taken all round the Irish coast, and is the most highly valued of all the flat fishes there, on account of its delicious taste. Rutty (i. p. 350) says it is sometimes called "the pheasant of the waters." The turbots of the Mediterranean and Adriatic often grow to a large size, and are celebrated in classic story. Very fine turbot are taken by the Dutch off the Flemish Banks.

*General habits.*—Usually found, like Pleuronectids in general, near the bottom, but frequently mounting upwards even to the surface over a depth of fifty fathoms. Prefers sandy or muddy ground, is a voracious feeder, but said to be somewhat particular as to the quality of its food; swims often in companies, but cannot properly be called a school fish like plaice; is a great wanderer, and, like the sole, resorts to deep water during severe weather. In warm, calm weather it often comes near the surface and seems to enjoy the sun.

*Food of.*—Other fishes; crustacea of various kinds, as crabs, *Xantho*, *Gonoplax*, *Portunus*, *Porcelanus*, *Eurynome*, scaly lobsters as *Galathea*, spider crabs (*Stenorhynchus*), *Ophiuridæ* or "brittle-stars;" molluscs and large worms are also consumed by the turbot.

*Spawning.*—Takes place in May, June, and July. The turbot is one of the most prolific fish known. In a specimen which weighed 23 lbs. Buckland found the roe to weigh 5 lbs. 9 oz. He computed the ova to be upwards of fourteen millions. This fish is known to spawn near the surface of the water. All the Pleuronectoids in their early stage are symmetrically formed and swim vertically like ordinary bony fishes (see Introduction). I have before me as I write two very interesting little turbot-fry which were captured by Mr. Dunn in a surface-net near Mevagissey, I believe in the month of July, 1882. One is slightly larger than the other; the largest is just $\frac{6}{10}$ of an inch in length including the caudal; the height of the body is as 1 to 2 in the total length, which is less by $\frac{3}{4}$ in the adult fish; both sides are equally coloured, and both equally thickly besprinkled with minute black pigment spots; each eye occupies a separate side; but when the little specimen is placed on its right side, the eye of that side can be discerned by the aid of a lens as having started to come over, or rather apparently round, to the opposite left side in the larger specimen; in the smaller one this initial transit is barely discernible; the bodies of both specimens are much compressed as in the adult fish, and externally, with the exception of the two coloured sides and an eye on each, the young turbot of $\frac{6}{10}$th of an inch long is very like one of 20 or 30 pounds. (Plate IV.) The microscope, however, reveals some other differences; the fin rays are or appear simple, but on examination with an $\frac{1}{2}$-inch objective, the splitting of each ray into the branched, or dichotomously divided parts, may be discerned. The pigment cells (*chromataphores*) appear as beautiful, distinct astero-dendritic marks; the dorsal-fin in the young specimen commences behind the eye, and not, as in the adult, before it. There are no externally visible bony tubercles of the skin in the young fish. In a specimen which Day examined, about 1$\frac{1}{2}$ inches in length and supposed to be about two months old, he speaks of the eye as still in transit, passing round the bones of the head. In this early state they swim on their edges. In the specimen before me there is scarcely any indication of a change in the colour of the right side to a lighter complexion, which, however, is not quite so dark as the left side. What time normally intervenes between the time of birth and the full assumption of the characters which belong to the adult form, is not, I believe, known at present. How long and under what conditions these young turbots continue to be surface vertical swimmers is also unknown. Rate of growth in fishes almost always depends on the abundance of suitable and nourishing food. In the Southport Aquarium, young turbots measuring 3 inches across, which had been caught in the nets of shrimpers, and which had been transferred into the tanks there, attained to the weight of 10 pounds in two and a half years; after another interval of two years they increased to 20 pounds, or an average of about 4$\frac{1}{2}$ pounds per annum. Some observations recorded in the 'Proceedings of the Zoological Society of London,' December, 1879, would seem to give 1 pound per annum as the rate of increase in fishes taken from Ballinskellig Bay, Ireland; a far smaller rate of increase than in the Southport Aquarium specimens. It is therefore quite probable that the artificial production and rearing of these fish would prove, on trial, to lead to successful results. Turbot attain to a great size. Thompson (' Nat. H. of Ireland,' iv. p. 200) mentions one caught off the county Down that weighed 44¼ pounds; Couch records one caught near Plymouth, in 1730, which weighed 70 pounds, and one is mentioned of 190 pounds caught in 1832 near Whitby, measuring 6 ft. across. "This," says Buckland, "I do not believe." The late Inspector of Fisheries had a cast of a fish in his museum at Kensington, which weighed 32 pounds. The largest I ever saw in a fresh condition weighed 25 pounds, and was sent to me as a present at Christmas time from the Isle of Man. We had no vessel large enough to cook the fish whole, and had to cut it up into suitable pieces for the pot. As Day says, confusions may have been sometimes made between turbots and halibuts, as in some places the halibut is called a turbot. Still there is no reason to refuse absolute credit to records of enormously large fish. There seems to be no reason why, under favourable circumstances, some fish should not continue to exhibit growth all their lives, and that their lives should not extend to a great number of years, as we know to be the fact in the fresh-water pike for example. (See Introduction.)

*Modes of capture.*—Chiefly by the trawl; but numbers are caught on the long lines or "boulters" as they are termed. In calm weather turbots are sometimes speared. Thompson (*l. c.*) writes: "Newcastle, Co. Down, April 16th, 1851.—To-day, and for several days past, the weather has been so calm and the sun so bright, that large quantities, chiefly of flat fish, have been taken with spears off Newcastle. These spears are 32 or 33 feet long, with an iron barb at the end, and the fishermen, seeing their prey at the bottom, even several feet deeper than the length of the spear, drive it at them, and the fish when struck rises on the spear to the surface. Fish, greatly finer than I have seen taken during the season on lines, have been captured in this manner for the last few days. Turbot between 20 and 30 pounds are sometimes so taken. Even gurnard are taken by the spear. There is no rope fastened to it that the fisher might retain in his hand. As baits fresh herrings, sand-smelts, pilchards, slices of other kinds of fish, and lamperns, are used for turbot; the latter are preferred by the Dutch, who excel in turbot fishing. The bait should be very fresh, as the turbot is somewhat fastidious, and will refuse any bait if it be tainted. Bright silvery bait, sufficiently tough to stand the usual effect of being secured to the hook, are the best. As a rule, fresh untainted bait is always preferred by fishermen, not for turbot only, but for basse and other kinds; and doubtless the olfactory nerves of fishes are keenly alive to unpleasant odours, and will reject such bait as a rule, exceptions perhaps being made in the case of a hungry cod, ling, or, other voracious gadoid." The question as to the possible effect of a decrease of numbers by catching a number of small turbots in the sandy bays in shrimp-nets or other small-mesh appliances will be found discussed, together with the objections to trawl fishing generally as destructive of the products of the harvest of the sea, in the Introduction. Turbot are taken off our coasts all the year round; but in severe weather the fish resort to deeper water, and the vessels must extend their voyages further from land and try their luck there. In the warm weather the fish resort to shallow water. The North Sea has long been celebrated for its turbot, especially along the Dutch coast; the Dutch used to send to the London market large supplies of turbot long before our trawlers had to any extent established themselves at Grimsby or on other parts of the east coast.

The turbot is a great wanderer, and may be scarce at one place and abundant at another; or it may be abundant in one place for several years, and again for some years be very scarce. There are doubtless difficulties attending the catching of turbots in large and sufficient quantities, depending on the great depth of the water which they inhabit during cold seasons, or on the rough nature of the ground, or the heavy seas, which render successful trawling a difficult task. The neighbourhood of the Wolf Rock, south of the Land's End and east of the Scilly Islands, has very deep water, and extraordinary catches of turbot have been made there, but the nature of the ground is not by any means favourable for trawling purposes, and such fishing is accompanied with more than ordinary risk.

*Quality of flesh.*—Firm, and excellent in flavour, rich and gelatinous; when quite fresh from the sea the flesh is somewhat tough; it improves decidedly by keeping a day or two with a light sprinkling of salt on it. The gelatinous skin and the thick fins are the parts most prized by epicures. One of the French names of the turbot, *faisan d'eau* "pheasant of the water"), expresses their opinion of the excellency of the flesh, while that of the sole is signified by the name *perdrix de mer* ("partridge of the sea"). According to Rutty ('An Essay towards the Natural History of the County of Dublin.' Dubl. 1772, 2 vols, 8vo.), the Irish had appropriated the name of the "pheasant of the sea."

*Commercial value.*—One of the most highly prized of all our sea fishes. Turbots are generally sold at so much each; in the wholesale trade at Billingsgate and Grimsby, Brixham, &c., from 4*s.* to 20*s.*, 25*s.* or 30*s.*, according to size, quality and demand. Buckland states that in June, 1870, a large quantity of turbot came into Billingsgate which had been taken on the fishing grounds about 40 miles from Heligoland; that one vessel, the *Night Hawk*, had no less than 1500 turbots; and that good turbots were selling from 1*s.* 6*d.* to 6*s.* Of course so large a catch made the fish cheap. According to Kröyer the turbot is tenacious of life. "When our fishermen in the Cattegat," he says, "capture a large turbot and cannot at once find a purchaser, they tie a line to its tail, or pass it through the mouth and gills, and fasten it to a stone, or to a post on the shore, and even though the water be very shallow the fish will live a long time, provided the weather be not too warm. The way in which it is conveyed in the 'well' of a vessel puts it to a still harder proof. After a line has been passed, as mentioned, through its mouth and gills, it is suspended in a perpendicular position to one of the deck beams, that it may not, by coming in contact with other fish, injure them with its prickles." This fish is in Sweden and Denmark as highly valued as by us, and "takes the same place at the table as the pheasant among birds."

*Classical allusions and names.*—There seems no good reason for abandoning the old idea that the *rhombus* of the Latin writers denotes the turbot. The word is of Greek origin, meaning either (1) a "top" (Lat. *turbo*, hence our English name turbot); (2) "a rhomb;" or (3) a kind of fish, so called from its rhomboidal form. The Greek word ῥόμβος does not occur in Aristotle's 'History of Animals.' He speaks of a fish called ψῆττα (*psĕtta*), said by Athenæus to be the same as the Roman *rhombus*, "which is also a Greek name." Aristotle's description of the *psētta* does not suit the turbot; he speaks of its burying itself in the sand and waving about the appendage of its mouth for the purpose of alluring other fishes. However, Ælian speaks of ψῆτται and ῥόμβος as flat fishes inhabiting and concealing themselves in the sand. Pliny mentions the *rhombus*, and says that it lies with the right side uppermost, which is not true of the turbot, which lies with the left side uppermost. Pliny says the rhombus moves about its fins like little worms. This would rather answer to the brill than the turbot, the anterior radii of whose dorsal fin are separated and form small filaments. The probable explanation is that similar-looking fish were often called by the same name; so that the rhombus, though generally denoting the turbot, occasionally refers to the brill. Juvenal's rhombus is clearly a turbot. The satirist represents a turbot of enormous size having been caught, not in the Mediterranean but in the Adriatic; it was therefore a foreign fish and worthy of presentation to Domitian.

> "Incidit Adriaci spatium admirabile rhombi
> Ante domum Veneris, quam Dorica sustinet Ancon
> Implevitque sinus" (iv. 39).

It was taken on the shore at Ancona, opposite the temple of Venus; the turbot of Ancona are still famed throughout Italy. This great fish, which was too large for any existing dish, requires the special aid of Prometheus to mould fresh clay for its size. When extended on the dish at the banquet, Veilato, "cæcus adulator," who thinks he can see in the turbot a mighty omen of a great victory for the Roman emperor, exclaims, "Do you not see spears erect on its back?" Couch considers that the erect spears ("sudes erectæ in terga," l. 128) refers to the osseous tubercles of the turbot's back, and not to the dorsal fins. The latter, however, are clearly meant. The long and strong fin-bones exposed to view on a dish after having been boiled are very conspicuous, and might well suggest the idea of spears or spikes. The *sudes* are the *cristæ* of the fish mentioned in the 70th line. The long dorsal fin-bones of the turbot suggested the idea of the spears of Domitian's army sticking in the backs of his foes, and therefore were an omen of victory. But the small inconspicuous bony tubercles imbedded in the skin of the fish could not suggest to the most fulsome flatterer the idea of horrid spikes of war. The ancient Romans used to fatten these rhombi with other pleuronectids in their vivaria. "In constructing your piscinæ," says Columella, (R. Rust. viii. 16. 7.) "you must pay especial regard to the nature of the place, for every kind of fish is not to be had from all localities. A muddy place suits the flat fish, as the sole, the turbot and the sparrow fish; sandy grounds suit some fish, rocky ground others." The *passer* of the Latins may have been the brill, so called from the brown colour of the fish's back. The turbot was, as is well known, highly esteemed as fish diet by the ancient inhabitants of Greece and Italy. In John Russell's 'Boke of Nurture,' under the title of "*Kervyng of Fische*," it is said, "Of bret, samon, congur, sturgeoun, turbut and some other fish, it is said 'alle these cut in the dish as youre lord etethe at meele'" (p. 41). The term "sea pheasant" is an old one. Muffett. p. 173, says, "Turbuts . . . some call the sea pheasant . . . whilst they be young they are called butts . . . They are best being sodden."

Our early English ancestors were very fond of using mustard as a sauce for fish; possibly our custom of eating fresh herrings with melted butter and mustard mixed, may be a relic of olden times. Let us hear John Russell again :—

> "Grene sawce * is good with grene fisch y here say ;
> Botte lynge brett & fresche turbut gete it who so may,
> Yet make moche of mustard, & put it not away,
> For with every dische he is dewest who so lust to assay."—(p. 29.)

The word *turbot*, spelt variously in the works of old writers, as *turbut*, *turbote*, *turbutte*, is from the Latin *turbo*, "a whipping top," "spindle," "reel," from its rhomboidal shape, and has precisely the same meaning as the Greek *ῥόμβος*. Skeat says that the low-Latin name *turbo* was used to denote a *turbot*; the final *t* or *ot* being the suffix. Some etymologists consider that the latter part of the name, *bot* or *but*, is the same as *butte*=a "plaice" or "flounder," as we have seen that *holibut* is "holy flounder;" but the origin of the first syllable *tur* remains to be explained. Littré hesitates to refer the name to the Latin *turbo*, because he thinks there is a difficulty in accounting for the last syllable, and also because the fish is not like "a top." But neither *ῥόμβος* nor *turbo* has this restricted meaning; the Greek word denotes also a "rhomb," the 4 equal-sided but only two opposite angles equal; and it is pretty certain that the Greek name includes the turbot, a fish which is nearly as broad as long, and therefore to a certain extent rhomboidal. Neither is *turbo* restricted in signification to a "top;" from the idea of a violent circular notion (*tur* = *torqueo*) that of a round figure followed; and the turbot of all the flat fishes answers the description of a circular fish. The occurrence of the word *turbo* in low-Latin to denote a *turbot* must settle the question. I have not, however, been able to find it in Du Cange. The Irish *turbit* signifies a *turbot* and a *rhomboid*; so that all the names must be referred, not to a Celtic, but a Latin origin. Satchell gives, as provincial names, Bannock-fleuk, bratt, rawn-fleuk, roan-fleuk and turbut.

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* Green sauce, "Vert sause," was made of herbs, bread crumbs, vinegar, pepper, &c. Grene sause is explained as *condimentum* *erbaceum*.

*General description.*—The height of the body is contained about $1\frac{3}{5}$ in the total length; scales absent; body on the upper sides is covered with scattered bony tubercles, those on head smaller and more numerous; lower jaw prominent; upper eye somewhat behind the lower; dorsal fin commences in front of the eyes on the snout (in the very young, behind the eyes); a very short space between the ends of the dorsal and anal fins, and the root of the caudal; the longest rays of the dorsal a little behind the middle of the fin; caudal fin rounded. Lateral line with a semicircular curve above the pectoral fin; no spine before the anal; colour greyish, sandy brown, or brownish with numerous dark spots and blotches. Under-side of the body white,—varieties seem to be numerous as to colour; sometimes the white and coloured sides are reversed; or the two sides may be coloured; or the under side may be pied; or they may be nearly white on both sides (albinos), still retaining their normal form. The eye in its transit from the right side to the left is sometimes arrested, and remains fixed on the under-side, in which case the fish is generally coloured on both sides. Donovan's figure of what he thought would prove to be a new species, which he called *Pleuronectes cyclops*, is simply a young turbot, or double flat fish, with an eye on each side. Hybridism has been observed in the Pleuronectidæ, and supposed crosses between the turbot and the brill are recorded.

### THE BRILL OR BRETT (*Rhombus lævis*).

*Rhombus lævis.* — Rondelet. x. 3, p. 312; Gesner, de Aquatil. p. 663; Willughby, p. 96.

*Rhombus alter gallicus.*—Bellon, p. 141.

*Rhombus non aculeatus.*—Willughby. p. 95, tab. F. J.

*Pleuronectes.*—Artedi, Spec. Pisc. p. 31. No. 5; Gen. p. 18, No. 8.

*Pleuronectes rhombus.*—Lin. Syst. Nat. i. p. 458; Lacép. iv. p. 649; Donovan, Brit. F. iv. pl. 94; Flem. Brit. Anim. p. 196; Jenyns' Man. p. 462; Thompson, Nat. H. Irel. iv. p. 201.

*Rhombus vulgaris.*—Yarrell, ii. p. 331; Parnell, Fish. Firth of Forth, p. 315.

*Rhombus lævis.*—Gottsche, Wiegm. Archiv, 1835, p. 175; Günther's Catal. iv. p. 410; Day v. pt. 14, pl. 97.

*Pearl flounder.*—Pennant, Brit. Zool. iii. p. 321.

*Brill.*—Couch, iii. p. 161, pl. 162.

*Geographical distribution.*—Coasts of Europe, from N. latitude 62°; the coasts of Sweden and Jutland, in the south Baltic; around the British Isles, through the Mediterranean. Hardly known on the western shores of Norway, and generally becoming scarcer towards the north. Rare in the Orkneys and Shetland, and at Banff; taken occasionally at Aberdeen, the Moray Firth, and abundant at St. Andrews; not uncommon off Yorkshire, and abundant in the Norfolk estuary, and more or less common off the eastern coast, and abundant along the southern coast. In Ireland the brill is common round the coast, and taken with the turbot, but is in much greater abundance than that fish on the north-east coast, at least 4 to 1 (Thompson).

*General habits.*—Very similar to those of the turbot, frequenting the same kind of ground ; enters the estuaries of large rivers, frequents sandy or muddy bays, and deep water in severe weather. It is not so voracious as the turbot.

*Food.*—Young or small fishes; worms, crustacea, and molluscs; at Grimsby in two I examined, I found the stomach of one empty; in the other were two sand-launces and a great deal of digested fish-food. In the stomachs of four fish from the Liverpool market, I found young herrings in the stomachs of all; and in one a tape worm more than a yard in length.

*Spawning.*—Probably in the spring or summer months, though the season very likely varies according to the locality and temperature ; Nilsson thinks it spawns about the end of May. Kröyer found the roe-lobes well developed, though small, at the beginning of November, and also in the same state in the early part of May. The mode of deposition of the spawn is at the surface like the turbot; their mode of development is doubtless very similar. Brill never attain a size or weight equal to that of the turbot. It does not often exceed 8 or 10 pounds in weight. Thompson says that the largest he had ever seen at Belfast was 2 feet in length. To what cause can we attribute the large size to which the turbot often attains, and the comparatively small size reached by the brill—a fish so like in general characters and habits? Probably the abundance and nutritious properties of the food lie at the bottom of the question.

*Modes of capture.*—By the trawl; much less frequently caught by the line than the turbot, which is a heavier feeder than the brill. In the Firth of Forth, however, it is said to be chiefly taken by the line.

*Quality of flesh.*—A very good fish, but far inferior to the turbot, and far superior to the plaice; it lacks both the firmness and flavour of the turbot, but is never watery like the plaice. A good thick brill is excellent eating; these fish are often bought from the fishmonger by the "unknowing ones" as turbot, as I myself can testify on more than one occasion. Brill are usually boiled and served up like turbot.

*Commercial value.*—Not half equal to that of the turbot. The usual wholesale selling price is from 2*s.* to 4*s.* 6*d.* or 5*s.* each, fine fish will fetch a little more at Grimsby; they are generally a little dearer at Billingsgate, 2*s.* 6*d.* to 6*s.* In bad weather when the supplies are short, brill will fetch 2*s.* 6*d.* to 8*s.* each. Formerly both turbot and brill were not much thought of. Thus Bp. Jeremy (vol. i. serm. 16) says, "to make thy meal of sauces, and to make the accessory become the principal, and pleasure to rule the table and all the regions of thy soul, is to make a man less and lower than an oglio, of a cheaper value than a *turbat.*"

*Names.*—The word *brill* is thought by Skeat to stand for *brithel*, formed by the diminutive suffix—*el*, from the Cornish *brith*, "streaked," "variegated," "speckled." This name appears to have originally belonged to the "mackerel." The Cornish word *brithel*, "a mackerel," has the plural, *brithelli*, contracted into *brilli*, and is derived from *brith*, "variegated." This explanation appears correct; for in Welsh *brithyll* is "a trout," and the Gaelic for "trout" is *breac*, which means "spotted." The *brill*, then, is etymologically "the spotted or variegated fish." *Bret* is evidently from the same Cornish word *brithel* in the singular number; *brit* properly being "a single fish," and *brill* the fish collectively. *Brett* is an old name, though t very general now, *brill* being commonly used.

Thompson says this fish is universally called *britt* in the Belfast market; it is, however, generally a provincial name at present. It is *brill* in the North of England, and London, and throughout the country; but *brett* in the Liverpool market. This name, variously spelt *bret*, *brett*, *birt*, *burt*, *berte*, occurs in John Russell's 'Boke of Nurture,' the form of *brill* not occurring there. Satchell gives the provincial names of *bonnet fleuk*, *kite*, *lugalee*, *lugaleaf*, *lugger-ley* and *pril;* this last is evidently *brill*, and explains another name, *pearl*, "pearly, spotted." Pennant says that in Devonshire and Cornwall it is also known as *kite*. *Lugalie* or *lugaleef* awaits explanation.

*General description.*—Height of body, about 2¼ in the whole length; lower jaw slightly prominent; lower eye in advance of the upper; interorbital space flat; dorsal fin commences on the snout, its anterior rays with brush-like fringes; longest rays branched and behind the middle of the fin; dorsal ends close to the base of the caudal, which is rounded; no spine before the anal; lateral line arching over the pectoral; gill-rakers thick and lanceolate, about half as long as the eye. Scales small, but distinct, cycloid, covering the head, except the snout and the vertical fins. Colour greyish-brown, or reddish sandy-brown, sprinkled over with minute pearly specks, correctly surmised by Yarrell as being the origin of one of the fish's names, "pearl," to which *brill* or *prill* is akin in meaning though not in derivation; the under-surface is smooth and white. These white pearly varieties sometimes appear as "large stellate white markings, on a very rich-coloured dark ground, looking precisely as if a shower of snow had fallen on the fish" (Thompson, p. 201). Couch speaks of "an example intensely black with a few white specks on the anal fin" (iii. p. 162).

## THE SAIL-FLUKE, MEGRIM, OR WHIFF
## (*Arnoglossus megastoma*).

GENUS *Arnoglossus*.*—Eyes on the left side; gape of mouth wide; teeth small, very fine, in one or two series in both jaws; none on the palate; present on or absent from the vomer. Dorsal fin commences on the snout; quite distinct from the caudal; dorsal and anal rays simple (Günther); scales of moderate size; deciduous. Lateral line highly arched above the pectoral; gill-membranes broadly united below the throat; gill-rakers styliform: branchiostegals six or seven; pseudobranchiæ present.

Seas of Europe, from the North to the Mediterranean; East Indian Archipelago.

*Passer Cornubiensis.*—Jago in Ray. Pisc. p. 163, f. 2.

*Pleuronectes megastoma.*—Donovan, Brit. Fish. iii. pl. 51; Fleming's Brit. Anim. p. 196; Jenyns' Manual, p. 465; Yarrell, ii. p. 342.

*Rhombus magastoma.*—Nilss. Skan. Fauna, iv. p. 641; Günther, Catal. iv. p. 411.

*Zeugopterus* (?) *velivolans.*—Sir John Richardson, second supplement to the second volume of Yarrell, p. i. The fig. here is better than in Yarrell (*l.c.* above), which, however, gives a good idea of the bony head.

*Arnoglossus megastoma.*—Day, v. p. 21. pl. 98 (fig. excellent).

*Geographical distribution.*—Coast of Great Britain; the Orkneys, where it is at times common; on our coasts it is a rare fish, except off the Devonshire and Cornwall coasts, where it is sometimes caught in tolerable quantities. These fish are almost daily to be seen at Brixham and Plymouth, brought in by the trawlers; are of occasional occurrence from the north to south along the eastern line of the Irish coast. Taken at all seasons.

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* Dr. Günther places the sail-fluke in the genus *rhombus*; Day, in that of *arnoglossus*. According to Günther *rhombus* is distinguished from *arnoglossus* by the presence of vomerine teeth, and by the jaw teeth forming a band; in *arnoglossus* there are no vomerine teeth and the jaw teeth are in a single series. By this definition the sail-fluke or megrim is a *rhombus*. Its general form, however, would rather refer it to an *arnoglossus*.

*General habits.*—Seldom comes within the bays near the shore, but is often driven by storms on the shore. It is probably not really very rare off our southern and south-eastern coasts, but not being in great request, is perhaps not brought to the markets. The habits of this fish are, in some respects, very peculiar. Most of our information is derived from Dr. Alex. Duguid, of Kirkwall, Orkney Islands, and from Mr. Robert Scarth, of North Ronaldshay, the northernmost isle of that group, where the sail-fluke is common. This fluke, says Dr. Duguid, is highly prized as an article of food, its flesh being firm and white. It does not take bait, and he only once saw it caught in a net; but it comes ashore spontaneously, with its tail erected above the water, like a boat under sail, whence its name. This it does generally in calm weather, and on sandy shores, and the country people residing near such places train their dogs to catch it. Mr. Scarth writes, "It is never caught by hook or by net; and I have in vain set ground lines for it in the South Bay, baited with lug-worms, limpets and sallocks; neither have flounders nor skate-nets, drawn there, inclosed a sail-fluke. It seldom comes to the shore earlier than October or later than April, though it is often driven by storms on the beach, entangled among seaweed. The great supply is, however, obtained in the following manner:—In the winter and early spring a pair of black-headed gulls take possession of the bay, drive away all interlopers, and may be seen at day-break every morning, beating from side to side, on the wing and never both in one place, except in the act of crossing as they pass. The sail-fluke skims the ridge of the wave towards the shore with its tail raised over its back, and when the wave recedes, is left on the sand, into which it burrows so suddenly and completely, that though I have watched its approach, only once have I succeeded in finding its burrow. The gull, however, has a surer eye, and casting like a hawk, pounces on the fluke, from which by one stroke of its bill, it extracts the liver. If not disturbed, the gull no sooner gorges this luscious morsel, than it commences dragging the fish to some outlying rock, where he and his consort may discuss it at leisure. By robbing the black-backs I have had the house supplied daily with this excellent fish, in weather during which no fishing-boat could put to sea. Close to the beach of South Bay, a stone wall has been raised to shelter the crops from the sea spray. Behind this we posted a smart lad, who kept his eye on the soaring gulls. The moment one of the birds made its well-known swoop, the boy rushed to the sea-strand, shouting with all his might. He was usually in time to scare the gull away, and secure the fluke, but in almost every case with the liver torn out. If the gull by chance succeeded in carrying his prey off to the rock, he and his partner set up a triumphant cackling, as if deriding the disappointed lad. Seals often pursue these flukes into the bay, and frequently leave serviceable morsels unconsumed. The sail-fluke exhibits its gambols most frequently before a storm, or when a thaw succeeds a frost. It is the most delicious fish of our seas, but loses its our by a day's keeping" (19th Feb. 1849. Richardson's d. suppl. to Yarrell, pp. 2. and 3). This account has been confirmed by Mr. Charles Thomson of North Ronaldshay, who supplied Couch with specimens.

*Food of.*—Young fishes and crustacea. Thompson found in the stomach of one a small dragonet (*Callionymus*) three inches long, and the remains of three small *gadi;* in another, three examples of whiting about the same size, and in a third he found only shrimp-like crustaceous animals; another stomach contained only a fragment of a shrimp-like crustacean; in the stomachs of two I examined at Brixham I found the remains of two or three small fishes; the stomach of one was completely filled, but they were too far digested for determination.

*Spawning.*—Nothing definitely known. A specimen examined by Thompson (Nat. H. Irel. iv. p. 204) on Oct. 31st had just shed her ova, as evinced by a few only remaining. The time therefore may be during the autumn. The ordinary size of the sail-fluke, judging from what I observed in Brixham and the Isle of Man, was from about nine inches to thirteen long; but larger are not unfrequently caught. Thompson mentions, as the largest he had seen, fish 22, 23 and 23½ inches in length. The length of the specimen described by Sir J. Richardson was 21 inches. "A small basket of fish taken about Newcastle (co. Down), and brought to Belfast on 2nd Sept. 1843, contained six specimens of whiff, five of which were about 2 feet in length." (Thompson).

*Modes of capture.*—By the beam-trawl; occasionally but rarely takes a bait, probably it is not often fished for. From the fish's large mouth and hungry look one would imagine it would not generally refuse a bait; but, as we have seen, the hook and line do not succeed in the Orkneys. Day mentions as bait the same kinds as those employed for taking other flat fishes, i.e., a slice of mackerel or pilchard.

*Quality of flesh.*—In my opinion, excellent, very nearly equal to the sole in quality. I am surprised at Day's verdict, who says, "of but little value; or, as Borlase remarked, good for nothing." Yarrell says, "from experience I can say that the flesh is excellent when fried, almost as good as that of the sole." It is highly prized in the Orkneys, as Duguid tells us. Like some other of the flat-fish the sail-fluke deteriorates by being kept; but I do not think that it loses its good qualities in a single day. Though the fish is devoid of thickness, and has not that depth of flesh which belongs to the common sole or to the variegated sole, yet the flesh, though near the bone, is very sweet and commendable. It should always be fried.

*Commercial value.*—It can hardly be said to possess any real commercial value; the fish brought to Brixham and Plymouth are not sent away to the distant markets, but consumed by the inhabitants; nevertheless, with the Devonshire and Cornwall people who know its merits, the sail-fluke (always called megrim there) meets with a ready sale at a cheap rate. It would probably not bear long journeys well; but as a local food fish it has, or it deserves to have, great value. Numbers are sold in Douglas, Isle of Man, under the name of "soles."

*Names.*—There is much confusion with respect to this fish's popular names, some of the names applied to this fish being also used for other kinds. The following names are those which are given as being in use for this fish: *Carter, lanthorn fish, mary sole, whiff, sail-fluke, lang-mou'd flook* and *megrim.* I never heard any other name than megrim—pronounced *mâgrim* in Devonshire and Cornwall—for this species; and on enquiry I found that the other names were entirely unknown to the fishermen and salesmen at Brixham. Mary sole is generally applied to the lemon sole (lemon dab) (*Pleuronectes microcephalus*);

*carter* is said to be a name used by the Cornish fishermen for this species; lanthorn fish refers to its transparency, which is certainly remarkable. The *megrim* is generally referred to the little scald-fish (*Arnoglossus laterna*), as by Yarrell, Couch, Günther, and Day. Probably *megrim* may sometimes have been used to denote this latter fish. Its ordinary name now, however, is "scald-fish;" and *megrim* is used only to denote the *Arnoglossus megastoma* in Brixham, Plymouth, and Mevagissey, so far as I could ascertain. By Mr. Edward Hanmer of Stockgrove, whose initials E. H. are to be seen appended to some of the notes in Pennant's British Zoology (Ed. 1812), the names of the *A. megastoma*, as known at Plymouth, are given as *French sole* and *megrim;* that of the *lanterna* as 'scald-fish.' *Whiff* seems to refer to the fish's habits in showing itself lively before a storm, when the winds blow or *whiffle* about. "White sole" is sometimes used in Ireland for this fish; but *whitches* (white soles) in the north-east of England generally stand for the *Pleuronectes cynoglossus.* *Arnoglossus* is the Greek ἀρνόγλωσσον, the name of a plant mentioned by Theophrastus (*Histor. Plant.* vii. 8, 5. &c.), probably the Plantago major, from a fanciful resemblance of the smooth flower stalk to a "lambs' tongue." It was given by Rondelet to the scald-fish which he calls *Solea levis,* as it is smooth and apparently destitute of scales. (See Gesner *de Aquatil.* p. 668).

*General description.*—Height of the body 3 in the total length; lower jaw prominent with a rounded projection of the symphysis; cleft of mouth wide and oblique; maxilla nearly flat, reaching to about the middle of the eye; interorbital space very narrow; teeth small, hair-like, in two series in the jaw; a few teeth on the vomer, absent from the palatine bones; dorsal fin commences in front of the eye on the snout; the dorsal rays being the longest about the last third of the fin; caudal rounded and distinct from the dorsal and anal; lower eye in advance of the upper; scales small and ctenoid, covering nearly the whole head and body, a row on each fin-ray; lateral line with a semi-circular arch over the pectoral; no spine before the anal; colour brownish or pinkish yellow, sometimes with scattered dark blotches; the Devonshire examples were often of a reddish or pinkish colour, reminding one of the appearance of a skinned rabbit; whole fish when held up to the light being very transparent, whence one of its names the 'lantern-fish.'

### Genus *Pleuronectes*.

There is great dissimilarity in the species comprising this genus. The divisions may be tabulated as follows; they are as given by Day:—

*A. Teeth compressed and lanceolate.*

*a. Lateral line almost straight.*

1. A spine before the anal fin.

1. *Pleuronectes platessa*, D. 66–77; A. 50–57. Inter-orbital ridge, rough.

2. *Pl. microcephalus*; D. 85–93; A. 70–76.

2. No spine before the anal fin.

3. *Pl. cynoglossus*, D. 102–115; A. 86–87.

*b. Lateral line strongly curved anteriorly.*

4. *Pl. limanda*, C. 65–78; A. 50–62.

*B. Teeth conical.*

*a. Lateral line with a slight curve anteriorly.*

5. *Pl. flesus*, D. 60–62; A. 39–45. Ossicles at the base of the dorsal and anal rays.

The temperate and Arctic seas both of the northern hemispheres.

### THE PLAICE (*Pleuronectes platessa*).

*Passer vulgaris.*—Bellon de Aquatil. i. p. 142.

*Passer.*—Gesner, p. 664.

*Passer Bellonii.*—Gallis, Plye; Anglice a Plaise.—Willughby p. 96, tab. F. 3.

*Quadratulus.*—Bellon. *l. c.* p. 143.

*Pleuronectes.*—Artedi, Spec. Pisc. p. 31 No. 1; Gen. p. 17, No. 1.

*Pleuronectes platessa.*—Lin. Syst. Nat. i. p. 456; Donov. Brit. F. i. pl. 6; Lacép. iv. p. 628; Nilss. Skand. Faun. iv. 612; Günther's Cat. iv. p. 440; Day, pt. v. p. 25 pl. 101.

*Platessa vulgaris.*—Flem. Brit. Anim. p. 198; Jenyn's Man. p. 454; Yarrell, ii. p. 247; Thompson, N. H. Irel. iv. p. 192. Parnell, F. of F. p. 201 tab. 37.

*Plaise—Flounder.*—Pennant, Brit. Zool. iii. p. 304.

*Plaice.*—Couch, iii. p. 181. pl. 169.

*Geographical distribution.*—The coasts of northern Europe from the North Cape to the Sound, common on the whole coast of Norway and in the Cattegat; fairly common in the southern parts of the Baltic; numerous and large on the coast of Jutland; found all around our coasts; abundant in the Orkneys and Shetland Isles, the Moray Firth, Firth of Forth, Banff, Aberdeen, Berwickshire, the coast of Yorkshire, the Dogger-Bank, coasts of Norfolk and Suffolk, and generally on the south coast. Abundant round the Irish coast; the commonest of all the flat fishes in the north of Ireland.

*General habits.*—A most decidedly gregarious or "school" fish. As many as a thousand are sometimes captured at a single haul; prefers sandy or muddy shores; swims very near to the bottom, and often hides in the loose sand; approaches the bays and shores in the spring months, and frequents deeper water during severe weather. The plaice appears to be very tenacious of life. Thompson (*Nat. His. of Ireland* iv., p. 194) writes: "An individual about 10 inches in length, taken on the 3rd of January, 1835, lived 30 hours after being removed from the water; it was kept for 10 hours in a very warm room and lay on a dry plate all the time."

*Food of.*—Consists chiefly of shell-fish; worms, as *Pectinaria Belgica* (*Amphitrite auricoma*, Cuv.), and *Aphrodita aculeata* "the sea-mouse," have been found in the stomachs of plaice. *The quality of the food which a fish consumes influences the quality of its own flesh as an article of diet;* and I consider that in the plaice we have a very instructive lesson on this subject. Enormous quantities of plaice are caught in the North Sea. On a trawling expedition which I undertook (July 16th, 1882), chiefly for the purpose of ascertaining the nature of various food, by an examination of their stomachs and intestines, I should say that fully one-third of the contents of the trawl consisted of plaice. I examined a great number of stomachs; I found in most various kinds of shell-fish, many *tellinæ*, small *solens* and *pectens;* I saw hardly any vestiges of crustacea in their stomachs; the whole intestinal tract was generally full of watery fluid, proving that solid food, such as crustacea or echinodermata, did not enter into the list of the plaice's diet to any extent. Soft molluscous animals appeared to me to be the plaice's food. On my return home I turned to Thompson's 'Natural History of Ireland;' that excellent naturalist had paid considerable attention to the contents of fishes' stomachs. I found that his examination corresponded in a marked degree with my own. His food-notes on the plaice, taken in Belfast Bay, July, 1838, are in substance as follows:—

Specimen 1st.—Stomach crammed with *Tellina tenuis*, with a few fragments of minute shells of *Mactra solida*.

Specimen 2nd.—Stomach entirely filled with shells of *Mytilus edulis* about ¼ inch long. July.

Specimen 3rd.—Contents the same, in August.

Specimen 4th.—Stomach entirely filled with young mussels (*Mytilus edulis*).

Specimen 5th.—Stomach filled exclusively with *Amphitrite auricoma* (*Pectinaria Belgica*).

These three last-named specimens were examined on the 30th of March.

Specimen 6th.—Stomach of a very large plaice contained five full-grown *Aphrodita aculeata* (sea-mouse), and remains of several *Buccinum undatum* (whelk), also remains of two species of decapode crustacea. June 10th.

Specimens 7th and 8th.—Two large plaice with the stomachs wholly filled with *Lucina radula* (*L. borealis*). April 9th.

Specimen 9th.—The contents of plaices' stomachs sent by Dr. Farran (April 7th, 1843,) to Thompson contained the following molluscs:—*Amphidesma* (*Scrobicularia*) *prismatica. Amph.* (*Scrobicularia*) *Boysii*, *Tellina tenuis*, *Trochus cinereus;* and one green sea-urchin, *Echinocyamus pusillus.* Specimens bought in Dublin Bay.

Specimen 10th.—Stomach and intestines of a large plaice caught in Belfast Bay were almost wholly filled with *Solen pellucidus* in fragments; in addition were fragments of young *Mytilus edulis*, a *Corbula striata* (*C. nucleus*, Forbes and Hanley), *Venus laminosa.* Mont. *Amphidesma Boysii*, and *A. intermedia.* April 21st.

Specimen 11th to 13th.—Stomachs of three fish taken at Groomsport were filled with remains of solens (razor shells), almost wholly of *S. pellucidus,* mixed with the young of the larger species.

" Mr. Hyndman informs me that he has at various times looked to the contents of the stomachs of plaice bought in Belfast market (in all upwards of a dozen), and that in every instance he found only fragments of *Tellina tenuis.*"

Thus it appears that out of 25 stomachs of plaice that had been examined all contained molluscs, with the exception of one which contained only the worm popularly known as the sea-mouse, that a few remains of crustacea were found only in a single fish, and that there is no record of the plaice feeding on other fish as witnessed by its stomach. Considering that crustacea enter largely into the food-diet of most of our fishes, and that in some form or other this food is almost everywhere attainable, it would seem that the plaice has no predilection for crustaceans. To this absence of the most nutritious fish-food that exists, is, I believe, to be attributed the poor quality of the plaice's flesh. Coupled with the absence of crustacean food is the absence also of other fishes as food; so that the plaice appears to be restricted to a molluscous diet; such diet being often little better than watery dabs of organisms which, though sufficient for the increase and growth of the fish, is not capable by itself of building up firm muscular texture. The plaice has in some parts of Europe been transferred to freshwater in which it has flourished. Cultivation here would probably result in a marked improvement in the plaice's flesh. A judicious supply of nourishing food would tend to form a firmer and less insipid flesh.

*Spawning.*—Generally in the spring, February and arch, but said sometimes to spawn in autumn, and early winter. The ova are deposited near the surface and float there; in very still water, Mr. Jackson, of the Southport Aquarium, found that the ova would sink to the bottom, but would float again on the water being slightly agitated. Mr. Dunn records, "the young are first seen in April close to land, swimming on the surface of the sea, on their side, with an eye on each side. In about a week after being first seen, they may be found in pools near the shore, about the size of a baby's finger-nail." Thompson's young fish of 3 inches in length, received from the south coast on the 1st of January, would appear to be the product of an autumn's deposit of spawn. The ova, which are numerous, are large compared with those of the turbot. Male plaice are, it is said, comparatively rare. The same is said to be the case with the common sole. The cause of this, if a *vera res*, awaits explanation. It is not easy to get hold of specimens of flat fishes which have not had their gills, stomachs, etc., taken out before being sent to market. The ovary-lobes of a female fish in spawn would naturally at once attract the eye and be preserved as part of the saleable fish, but the milt-lobes have not the same value and attractiveness, and are perhaps often unnoticed. Plaice do not grow generally above 5 or 6 lbs., and that is a large size. Buckland had a cast in his museum of one weighing 10 lbs. The weight of 15 lbs. is recorded. The usual length is from 10 to 14 inches.

*Modes of capture.*—Chiefly by the trawl. Some are taken by hook and line on "foul ground," i.e., ground too rough for the trawls; great numbers are taken along the Antrim and Down coasts on long lines. Lug-worms and pieces of the flesh of conger-eels and herrings, especially the latter, are used for bait. In the case of a seine-net being used care must be taken that the net does not "roll," or the plaice "will sand;" they will sink with marvellous rapidity into the sand and the net will pass over them. On the south coast of England, during the summer, plaice are caught by the spiller, which is only a kind of bultey on a small scale. In the seas of northern Europe they are sometimes speared when the water is clear.

*Quality of flesh.*—Soft, woolly and insipid; perhaps one of the most disappointing sea-fish that swims; its clean appearance and bright orange spots beguile one into the belief that the flesh is as good as the colour is pretty. The very odour of the plaice deceives one—it is not fishy and unpleasant, difficult to describe, but very marked. It is supposed to be in best season about May. The fishermen of Kent say the plaice is not at its best till it has "tasted May water." The quality of its flesh may to a certain extent be influenced by the locality inhabited, but I never tasted either a mud plaice or a sand plaice that was good for much. Nevertheless, where nature fails art may supply a remedy. First filleted, then fried and nicely served with good rich sauce, plaice are tasty food. When filleted soles are ordered for dinner in many an hotel, filleted plaice are often substituted; in this way, the fish concealing its form discloses nothing to the eye, and the good sauce deceives the palate. Mr. Cornish's observation, that fish from a hard, close killas sand are better than those from gravelly sand, is quite correct. Mud which harbours worms is an essential element in fish life, clean sand is valueless.

*Commercial value.*—On account of its extraordinary abundance the plaice holds an important place in a commercial point of view. Hundreds of thousands are annually sold and consumed by the poorer classes. By the London "street sellers" plaice occupy the second place among all the fish sold by them, herrings come first, and mackerel third. Fishmongers recognise two kinds of plaice; one has no spots or only a few, the other is brilliantly marked with spots and termed by them "diamond plaice." Most of the latter are taken off the Dutch coast. Plaice, like nearly all other fish are dearer than formerly; *2d.* or 2½*d.* per lb. was once the ordinary price, now *4d.* is nearly always asked. At Grimsby, where enormous quantities of plaice are brought, the wholesale price of full boxes varies from 12*s.* to 24*s.* per box, but in rough weather even levels will fetch as much as 26*s.* to 33*s.* per box. Generally speaking all fish is dearer during the season of Lent.

*Names.*—The meaning of the word *plaice* is clear. It is variously spelt in old English, as *plaice*, *playce*, *place*, *plaise.* In John Russell's 'Boke of Nurture' instructions are given to wash them well, cross the flesh with a sharp knife, and use ale or wine sauce with them, or sprinkle them with salt ale and wine. Mouffet (p. 164) says, that if either plaice or soles be "once stale, there is no flesh more carrion-like, nor more troublesome to the belly of man." The old French *pläis* has not suffered so much from phonetic decay as the ordinary French literary name *plie*, and like our own name carries with it the stamp of its Latin origin, *Platessa*, the *t* only being lost in sound. *Platessa* is not a common Latin word in classical writers. Ausonius mentions "molles platessæ," but one cannot say what fish is denoted thereby. The provincial names of *plaish*, *plash*, *plasher*, *plash fleuk*, are all from the same Latin word *platessa*, that for πλατος "broad" or "flat." The Danish *röd-spætte*, Swedish *röd-spätta*, "red-spot" refers, of course, to the large bright coloured spots on the fish's upper surface.

*General description.*—The height of the body is about

2⅔ in the total length; eye, on the right side; the lower one in advance of the upper; the two eyes are divided by a narrow smooth ridge; lower jaw in advance of the upper-jaw, which has a row of about 24 narrow closely set teeth on the blind side; the teeth of the lower jaw are fewer in number; an ascending curved row of bony tubercles from the lower orbit of the eye joining the lateral line; scales small cycloid, a few on the cheeks. Lateral line only slightly curved above the pectoral. A spine before the anal fin; the dorsal fin commences near the middle of the eye, the longest rays being about the 38th or 40th from the head. Gill-rakers short and widely set. Colour brown (of different shades), with large orange spots.

### THE SMEAR-DAB OR LEMON-DAB (*Pleuronectes microcephalus*).

*Rhombus lævis cornubicus.*—Jago, in Ray, p. 162, fig. 1.

*Pleuronectes microcephalus.*—Donov. Brit. Fish. ii. pl. 42; Nilss. Skand. Faun. iv., p. 609; Günther Catal. iv. p. 447; Day, v. pt. 28, pl. 102.

*Platessa microcephala.*—Flem. Brit. Anim., p. 198; Jenyns' Man., p. 457; Parnell, Fish of F. of Forth, p. 206, tab. 38; Yarrell, ii. pt. 309; Thompson Nat. Hist. of Ireland, iv. p. 196.

*Pleuronectes cynoglossus.*—Nilss. Prodr. Ichth. Scand., p. 53 (not Skand. Faun.)

*Smear-Dab, Flounder.*—Pennant, Brit. Zool. iii. p. 309, pl. 47.

*Lemon Dab, Smooth Dab.*—Yarrell, ii. 309.

*Smear Dab.*—Couch, iii. p. 187, pl. 171.

*Geographical distribution.*—The northern coasts of Europe from Iceland to the British Isles and the French coast. According to Steindachner it occurs off Kamtchatka. As it is an Icelandic fish it has probably an extended northward range; does not seem to occur frequently in the Orkney and Shetland Isles, nor is it common off the Scottish coasts. It is not common off Berwick, but on the Yorkshire coast it occurs pretty abundantly. It is frequently taken on the Suffolk coast, where it is called *town dab* (Yarrell). On the south coast it is often plentiful, and is well known in Devonshire and Cornwall, where it is generally spoken of as the "Mary sole" or "Merry sole." Great numbers are sometimes taken in the North Sea, and the Grimsby Dock Market shows a general daily supply from July to January and February. Thompson says it is occasionally taken round the Irish coast, but nowhere in any large numbers.

*General habits.*—The smear-dab is more of a frequenter of stony or rocky ground than most of the flat fishes, hence its Swedish name of *berg-skädda* or rock-flounder. These fish appear to frequent our shores chiefly in the spring, though they are to be seen in some of the markets at all seasons. After spawning in April, as is thought, they retire into deeper water, whence, however, they are taken by the trawl in considerable numbers.

*Food of.*—Molluscs and worms. Thompson found one specimen full of large worms (*Nereis*), with nothing else in the stomach. Crustacea are said also to enter into this fish's diet. From the small size of the mouth one would infer that the food must be small, or if large, as some worms, very compressible. Couch thinks that its usual food consists of algæ and the entomostracous crustaceans.

*Spawning.*—Probably in April, but definite information is needed. Thompson obtained small specimens of 7¼ inches in length by $2\frac{1}{4}$ in breadth in the dredge from Belfast Bay in October; showing an elongated form when compared with the rhomboidal shape of the adult fish. He also found on the 17th of April a vast number of ova about half the size of ordinary clover-seed in a female he examined. The usual size of the lemon-dab is about 12 inches, but it attains to 18 or 20 inches in length. Kröger, from an examination of the organs, believes the ova are shed in the autumn and winter; Nilsson in July. Perhaps there is a difference dependent on localities and temperature.

*Modes of capture.*—By the trawl. In Orkney it has been sometimes taken with a baited hook, which of course must be very small.

*Quality of flesh.*—As superior to the plaice as it is inferior to the sole. In October and the winter months the flesh is fairly firm and good. It is not equal to the common dab (*Pleuronectes limanda*), but much depends on the time of the year when captured. I have sometimes thought a lemon-dab a good substitute almost for a sole; at other times I have considered it little better than a plaice. Thompson's verdict agrees with my own: "Much better than plaice, not so good as sole, nor so sweet as the dab." The lemon-dab is a very thick fish; it is best fried or filleted.

*Commercial value.*—Large quantities are sold annually throughout the country, and the fish meets with a ready sale. The usual retail price is about 8*d.* per lb. At Grimsby, the wholesale price is from 6*s.* to 8*s.* 6*d.* or 9*s.* per stone. They are not specially quoted in the London Market. On the whole, the lemon-dab is a commendable fish, and valuable as food when other and superior kinds are dear. In the trade this fish is never called *lemon-dab;*

it does not sound so well; it is always called *lemon-sole*, for obvious reasons.

*Names.—Lemon-dab*, from the yellow colour of the upper part of the body; but this yellow is not always marked. The yellow is often dark and dull. However, bright specimens such as that figured by Couch (Vol. III., pl. 172) are not very uncommon. The term *smear-dab* owes its origin to the thick mucous slime which covers the body. Satchell ("Provisional Index to a Glossary of Fish Names," p. 9) gives among the number the following: Bastard-sole, kitt, maiden-sole, mary-sole, Norway-sole, queen, sand-dab, sand-fleuk, small-headed dab, smooth-dab, witch.

*General description.*—Height of the body about 2½ in the total length. The lower eye in advance of the upper, from which it is separated by an elevated ridge; teeth in either jaw in a series of about 12, on the blind side conical and blunted; jaws of equal length; scales small, cycloid, covering the head; no spine before the anal fin; dorsal commences above the centre of the eye, the rays being longest in the posterior half of the body; lips thick (hence a Swedish name *pludder-mun*). Lateral line slightly curving above the pectoral. Colour, brownish, yellowish brown or yellowish, often with dark blotches; gill-rakers short, then pointed and closely set.

### THE CRAIG-FLUKE, POLE OR WHITCH (*Pleuronectes cynoglossus*).

*Pleuronectes cynoglossus.* — Lin. Syst. Nat. i. p. 456; Nilss. Skand. Faun. iv. p. 263; Günther's Catal. iv. p. 449; Day, pt. v. p. 30. pl. 103.

*Platessa pola.*—(Cuv. Règn. Anim.); Jenyns' Man. p. 458;

Parnell, Fish. F. of F. p. 210. tab. 38; Yarrell, ii. p. 315; Thompson's Nat. Hist. Irel. iv. p. 197.

*The pole or craig-fluke.*—Yarrell (l. c.).

*Long-flounder.*—Couch, iii. 190. pl. 173.

*The whitch.*—Of the North Sea, Grimsby and north-east markets.

*Geographical distribution.* — North Sea, around Great Britain and Ireland to the coasts of France. Found also on the North American coast; occasionally found on the coasts of Scotland, but not common anywhere. According to Thompson it is taken on the north-east, east and south-west coasts of Ireland. The craig-fluke seems to be nowhere commonly met with except in the North Sea, from whence the Grimsby trawlers bring a quantity to the market almost daily throughout the year. On the Cornish and Devonshire coasts this fish is scarcely known, and the name of "whitches," so frequently used in the north-eastern markets, is utterly unknown southwards. It is, however, now and then captured in Cornwall and Devonshire; but it is certainly a rare fish in those waters, otherwise Mr. Dunn, who for years has paid great attention to all sorts of fishes, would have noticed it there, had it occurred in any quantities. Mr. Dunn says it is rare at Mevagissey; the same testimony is given by Mr. Cornish, who has also paid much attention to the southern fishes. Yarrell and Couch both regard this fish as among the rarest of flat fishes. But North Sea trawlers were little known in Yarrell's time.

*General habits.*—Its habits are little known. In Denmark its name of "rock-dab" betokens a rocky habitat, at all events during a part of the year. Its chief resort, however, must be in the sand, or mud, because many are caught by e trawl, which cannot be worked when the ground is rough and stony. Young specimens are not met with near the shores, and the adult fish are taken in deep water at all times of the year; so that it is probable the craig-fluke is more of a permanent deep-water resident than the rest of the *Pleuronectidæ.*

*Food of.*—Molluscs chiefly; small fishes, worms, *Ophiuræ,* and occasionally crustacea. I have found worms, and crustacea (*Gammaridæ*) very sparingly in the stomachs, the whole contents of which are rathers oft and watery.

*Spawning.*—Probably in June, July, and August. On the 5th of May, Thompson found the ova moderately developed; Krozer, on the 22nd of July, found in a female 17 inches long, the roe about 8 inches in length ready for spawning, which he concludes takes place in the Norwegian waters early in August. This opinion is in accordance with that of the Swedish fishermen.

The ova most probably float at the surface and undergo development there, and, as was said, this occurs at a considerable distance from land. The usual size is about a foot. Lacépède says it attains a length of 24 to 30 inches. I found the ova in a female on the 8th August largely developed, and nearly mature. Intestinal flukes of a red colour I have observed in some specimens.

*Mode of capture.*—By the trawl exclusively.

*Quality of flesh.*—I think far superior to the plaice, but not equal to the lemon-dab, than which it is much thinner; the flesh is soft, but "passably good," when you cannot get anything better. Its very moderate good qualities I attribute to the comparative abstinence from a diet of crustacea. Apparently living at considerable depths, and seldom coming to the surface except at spawning time, the small crustacea, as *entomostraca* and crab-larvæ, would not be eaten, while its small mouth would prevent its swallowing the larger crustacea. It is best fried, but is generally too thin to fillet.

*Commercial value.*—Forms a not inconsiderable part in fish commodity at Grimsby, from whence the markets at Sheffield, Manchester and other great towns are supplied. The *Pleuronectes cynoglossus* is known there by the name of *whitches* and by no other name; numbers are sold at all times throughout the year. At Grimsby the ordinary price wholesale is from 10*s.* to 20*s.* per box; to-day as I write, March 13th, they are 36*s.* per box,—"small supply, demand strong." These fish are scarcely known in the London market.

*Names.*—Craig-fluke or crag-fluke refers to its supposed occasional resort to rocky places; compare the Norwegian word Skjœrising, "rock-dab." The pole was suggested first by Jenyns, as being in unison with the Latin word *pola*, which the fish received from Cuvier, but what the Latin word *pola* means or why this fish is called pola I know not. "Whitches" is doubtless an abbreviated corruption of "white soles."

*General description.*—Height of body about 3¼ to 4 in the total length; eyes on the right side separated by a sharp bony ridge; upper jaw with a row of about 20 incisor-like teeth, somewhat obtuse on the blind side; lower eye in advance of the upper; gape of mouth moderate. Scales small, not ciliated; very small imbricate scales covering the head; dorsal fin commences near the middle of the eye; the rays are the longest near the centre of the body; but the dorsal ray-fringe is nowhere deep. No prominent pine before the anal fin; lateral line not arched over the toral, proceeding in a straight line to the tail. Gill-rakers short and distant. Colour, greyish brown or brownish pink, fins sometimes dotted.

*b. Lateral line strongly curved above the pectoral..*

### THE COMMON DAB (*Pleuronectes limanda*).

*Passer asper.*—Rondelet, xi. c. 9, p. 319; Willughby, p. 97, tab. F, 4.

*Limanda.*—Bellon, de Aquat. p. 145; Gesner, pp. 665, 781.

*Pleuronectes.*—Artedi, Spec. Pisc. p. 33, No. 9; Gen. p. 17, No. 2.

*Pleuronectes limanda.* — Lin. Syst. Nat. i. p. 457; Lacép. iv. p. 621; Donov. Brit. Fish. ii. p. 44; Nilss. Skand. Faun. iv. p. 627; Thompson, Nat. Hist. Irel. iv. p. 195; Günther, Catal. iv. p. 446; Day, pt. v. p. 31, pl. 104.

*Platessa limanda.*—Flem. Brit. An. p. 198; Jenyns' Man. p. 456; Yarrell, ii. p. 307; Parnell, Fish. Firth of Forth, p. 205, pl. 37.

*Dab-flounder.*—Pennant, Brit. Zool. iii. p. 308.

*Dab.*—Couch, iii. p. 185, pl. 170.

*Geographical distribution.*—The coast of Northern Europe, Iceland, the North Cape, the western coast of Norway, the Baltic, Gulf of Finland; on most parts of the British coasts and the French shores. Common on all the sandy parts of Great Britain, found in the Orkney and Shetland Isles, in the Moray Firth, Banff, Aberdeen, St. Andrews, Berwick, &c. Abundant off the Yorkshire coast, Yarmouth, Norfolk, Devonshire and Cornwall. The dab is found round the Irish coast, but not in very great numbers—much of the Irish coast being rocky and not so well suited to the sand-loving habits of these fish. Templeton noted it as "a rare fish in Ireland," probably as it was not much brought to market. Thompson says it is seldom seen in Belfast market. At Portsmouth it is the most common kind of flat fish brought up by the trawl.

*General habits.*—An essential lover of the sand, and found in deep water and in shallow.

*Food of.*—Molluscs, worms, small fish and crustacea. Thompson found in the stomachs at various periods young mussels (*Mytilus edulis*), *Solen pellucidus*, *Nucula*, *Pagurus Bernhardus* (hermit crab), and *Aphrodita aculeata* (sea mouse). Corallines and *Sertularia* are also found in the stomach of the dab. Sundevall found the stomachs of several filled with small crustacea (*Idotea*). In stomachs I have examined, I have found remains of solen-shells and crustacea. Here in the dab is another interesting example of the influence which the fish's diet exercises on the quality of its own flesh. The flesh of the dab is excellent and few better flat-fishes can be found. Crustacean remains are generally apparent in the stomachs and intestines, and clearly form part of its usual food. The contents of these organs are not a watery mass like those of plaice and whitches, which rarely feed on the solid flesh-producing crustacea.

*Spawning.*—April, May, and June; sheds its spawn in sandy bays, and perhaps also in deep water at a distance from land. Couch found the roe ready to be shed at Christmas. Thompson found ova very minute in a female on the 15th of March; young dabs, about 1¾ inches in length, have been taken from the mouth of the Thames in the month of November, which would doubtless be the produce of the same year's summer hatching. The ova probably float and undergo development near the surface. I saw a great number of dabs taken by the trawl in the North Sea, 60 miles from land, in July; those I examined were destitute of ova and had spawned. The fact that certain fishes are known to spawn near the coast, by no means precludes the possibility of the same kind of fish spawning also in distant water. A very important consideration, indeed, viewed in connection with proposed legislation prohibiting the capture of immature sea fishes (see Introduction). Thompson says that young ones, under two inches, are commonly taken in Belfast and Strangford Loughs in the dredge, and they have nearly always white spots on their body. The usual size of a dab is about 8 or 9 inches, and it does not often exceed a foot in length.

*Modes of capture.*—By the trawl and seine nets, also by hand lines and deep sea lines (spillers) baited with squid, mussel, and lug worms.

*Quality of flesh.*—One of the best of all our flat-fishes ; it is a pity it does not grow to a larger size. It is not generally eaten by the higher classes, with whom custom and fashion prevail to a ridiculous extent. They are very good from January to April, and from October to the following January. A fried dab is a well-flavoured and fairly firm fish. Gesner, 'De Aquatil.' p. 665, says "its flesh is white, tender, not dry, and little inferior to the sole."

*Commercial value.*—Large numbers are sold almost daily at Grimsby, where the wholesale price varies from 4*s.* to 10*s.* 6*d.* per basket. Brixham and Plymouth also supply quantities of dabs, brought in by the trawlers. As an excellent cheap fish diet the dab deservedly holds a high place. Numbers are brought to the London markets, the street-sellers disposing of the greater proportion to the poorer classes.

*Names.*—The word *dab,* "a small mass of soft substance," is not a complimentary name for this little fish, but the word denotes anything small, irrespective of its quality. *Sattie* and *salt water fluke* are used in Edinburgh, to distinguish it from the flounder which is frequently found in fresh water. The specific Latin epithet *limanda* is a derivative from *lima*, "a file," from the roughness of the scaly surface of this fish. Hence the epithet *asper*, of Rondelet, Gesner, &c., in whose days the dab was by the English known as *brut*.

*General description.*—Height of body about $\frac{1}{2}$ in total length excluding the caudal, lower jaw prominent, lower eye a little in advance of the upper; eyes separated by a flat ridge; upper jaw with a row of about 22 narrow closely-set teeth on the blind side. Dorsal fin commences a little before the middle of the eye, the longest rays being between the 37th and 40th; pectoral nearly two-thirds the length of the head. A spine before the anal fin, caudal fin distinct from the dorsal and anal; lateral line without tubercles, and with a strong curve above the pectoral; scales small and ciliated; on each dorsal and anal ray there is a single row of minute scales. Colour, brown or pale brown, or yellowish brown with numerous yellow spots.

## THE FLOUNDER OR FLUKE (*Pleuronectes flesus*).

*Passer fluviatilis* vulgo *flesus.*—Bellon, p. 144; Willughby, p. 98, tab. F, 5.

*Passeris* tertia species.—Gesner, pp. 666, 782, 788.

*Pleuronectes.*—Artedi, Spec. Pisc. p. 31, No. 2; Gen. p. 17, No. 4.

*Pleuronectes flesus.*—Lin. Syst. Nat. i. p. 457, Donov. Brit. F. iv. pl. 94; Lacèp. iv. p. 633; Nilss. Skand. Faun. iv. p. 618; Günther, Catal. iv. p. 450; Day, pt. v. p. 33, pl. 105.

*Platessa flesus.*—Flem. Brit. Anim. p. 198; Jenyns' Man. p. 455; Yarrell, ii. p. 303; Thompson, N. H. Irel. iv. p. 194.

*Common flounder.*—Pennant, Brit. Zool. iii. p. 305.

*Flounder.*—Couch, iii. p. 195, pl. 175.

*Geographical distribution.*—Iceland and the coasts of

Northern Europe to those of the British Isles and France; generally abundant round our shores where the bottom is soft mud, sand or clay; frequents especially the mouths of large rivers, which it ascends for a great many miles where not impeded by weirs or other obstructions; common on the sandy and muddy shore of Scotland and Ireland.

*General habits.*—Most aquatic of all our flat fishes, being at home as well in fresh water as in salt or where the water is brackish; used to ascend the river Severn as far as Shrewsbury, where some years ago it could be successfully angled for; but their ascent has for some years been stopped by weirs at Worcester and Gloucester. Like other pleuronectes the flounder loves to conceal itself in the mud or sand, with its head and eyes protruding, ready for pouncing on passing prey. They have been transferred to freshwater ponds with success. It is quite probable that a judicious treatment in suitable water, with abundant supplies of nutritious food, would result in the improvement of this fish as an article of diet. At present the flounder, but not this species, is chiefly interesting in a zoological point of view as the fish on which Professor Alex. Agassiz has experimented in his researches on the life history and development of the Pleuronectes (see Introduction).

*Food of.*—Worms, molluscs, young fishes. It does not appear to consume much crustacea food.

*Spawning.*—From February to the end of April. The ova float near the surface, where they undergo development (see Introduction). The ordinary size of a flounder is about 8 or 9 inches in length. It never attains the size of the plaice; a flounder of 4 lbs. would be an unusual size, though fish of greater weight are recorded.

*Modes of capture.*—Often taken in tuck-nets or by spillers baited with lug worms or a piece of fish or mussel. In shallow water the Norwegian fishermen sometimes spear them; if the surface of the sea is ruffled a little train oil is poured out, which causes the sea to become smooth and enables the fisherman to see objects at the bottom. Flounders are greedy biters, and I remember, many years ago, catching daily considerable numbers in the tidal streams near Birkenhead with a rod, float, and worm. I have seen great quantities of these fish taken at Southport from one to four inches long in the nets of the shrimpers. In the neighbourhood of Warrington many people from the neighbourhood resort to the rivers for fluke fishing.

*Quality of flesh.*—Variable; soft and often muddy. Some people, however, think it very good when fried. But much depends on the localities where captured; and experiments on this fish with a view to improve its edible qualities are desired. River fish are said to be firmer and of better flavour than sea-fish.

*Commercial value.*—Great numbers are sold in London, being taken from the Thames, where they abound. The usual wholesale price at Billingsgate is from 1*s.* to 1*s.* 6*d.* for twenty-six. Flounders do not "figure" in the Grimsby market. Mayhew ('London Labour and London Poor,' p. 69, vol. i.) gives as the annual number sold by the London street sellers, who carry on the chief business, 260,000, or 43,000 lbs. weight. Dabs are estimated at 270,000, with a weight of 48,000 lbs.

*Names.*—Our word *flounder*, the Swedish *flundra*, Danish *flynder*, is probably connected with the verb "flounder," a nasalised form of the Dutch *flodderen*, "to flap," "splash through the mire," (see Skeat, s. v.) Flounders are
ned in John Russell's 'Book of Nurture.' Verjuice
amon are recommended as ingredients for the

sauce. Satchell gives as provincial names, *black-butt*, *butt*, *fleak*, *floundab*, *fluke*, *freshwater-fleuk*, *hand-butt*, *mayock-fluke*, *plaice*. The word *fluke*, Anglo-Saxon *flóc*, is explained as "flat-fish" plaice, "sole." It seems to be connected with the Swedish *flunnka*, "to swim."

*General description.*—Height of body about 2½ in the total length; lower jaw prominent; eyes prominent and separated by a bony ridge, the lower slightly in advance of the upper; upper jaw with a double row of small obtuse teeth, those of the outer row being about 15 in number on the blind side. The dorsal commences opposite the middle of the eye, its broadest rays being at the posterior half of the body; scales minute, cycloid, rudimentary ones on the cheek; along the base of the dorsal and anal fins is a row of bony tubercles, also a bony ridge from the upper eye to the lateral line. Lateral line very slightly curved above the pectoral fin, and having rough tubercles along its course. Gill-rakers small, lanceolate, and rakers widely set. Colour depends on the nature of the ground on which it is found; usual colour brown of various shades, olive brown with or without dark blotches; under surface white. Thompson saw two examples of flounder which exhibited the orange spots of the plaice. Double flounder (coloured on both sides), reversal ones, semi-albinoes, rosy coloured flounders occur (see Introduction).

## THE SOLE (*Solea vulgaris*).

*Genus Solea.*—Eyes on the right side; the upper being in advance of the lower; cleft of mouth narrow, distorted towards the left side; teeth in the jaws small, confined to the blind side in villiform rows, absent from the vomer or palatine bones. Dorsal commences in advance of the eye, and is distinct from the caudal; scales very small, ctenoid.

Lateral line straight. Pectorals developed, rudimentary or absent. Nostrils variously formed.

The genus solea has been subdivided according to the presence of the pectorals and the form of the nostrils.

A. Pectoral fins developed on both sides.

*a.* Nostrils on the blind side not dilated.—*Solea vulgaris.*

*b.* One of the nostrils dilated and fringed.—*S. aurantiaca* Günth., *lascaris* Day.

B. Pectorals both very small.—*S. variegata* and *S. minuta* (*lutea* Day).

C. Pectorals quite absent; no British forms.

The members of this most valuable genus are found in all the seas of the temperate and tropical regions, "except the southern portion of the south temperate zone" (Day). Some enter fresh waters and thrive well there.

Βούγλωσσος.—Athenæus, vii. 288, 330; Oppian, Halieut. i. 99.

*Solea.*—Pliny, ix. 16, 20; Ovid, Hal. 124.

*Lingulāca.*—Varro, de Ling. Lat., 5, 12, 23 & 77.

*Buglossus* v. *Solea.*—Bellon, de Aquat. p. 145; Rondelet, xi. c. 11, p. 320; Gesner, iv. pp. 666, 671; Willughby, p. 100, tab. F, 7.

*Pleuronectes.*—Artedi, Spec. Pisc. p. 32, No. 8; Gen. p. 18, No. 6.

*Pleuronectes solea.*—Lin. Syst. Nat. i. p. 457; Lacép. iv. p. 623; Donov. Brit. Fish. iii. pl. 52;

*Solea vulgaris.*—Flem. Brit. Anim. p. 197; Nilss. Skand. Faun. Fisk. p. 651; Jenyns' Man. p. 466; Yarrell, ii. p. 347; Parnell, Fish of F. of F. p. 218; Günther, Catal. iv. p. 463; Day, pt. v. p. 39, pl. 186.

*Sole flounder.*—Pennant, Brit. Zool. iii. p. 311.

*Sole.*—Couch, iii. p. 200, pl. 176.

*Geographical distribution.*—Northern coasts of Europe as far as lat. 62°; occurs in the Southern part of the Baltic, around the British shores and those of France, and in the Mediterranean. Not common in the Orkneys and Shetlands, nor at Banff; said to be common in the Moray Firth, "but not much sought after;" sparingly found at the mouth of the Firth of Forth; more common off Yorkshire; becoming abundant southwards, as in Norfolk and the coasts of the English Channel; abundant and especially fine in Devonshire and Cornwall. On the west coast, as in the Bristol Channel, Cardigan and Carnarvon Bays, the sole is more or less abundant; but little trawling is carried on off the Welsh coast, except at Pwllheli, where great numbers are captured.

Around the Irish coast the sole is found, and on some banks large quantities of the finest quality are taken; those found in the North of Ireland are said by Thompson to vary considerably in form and colour from those of the south. Soles are far from common in the North Sea; most are taken off the Dutch coast and these not often of any large size.

*General habits.*—Like most of the flat fishes, the sole prefers a sandy, gravelly or muddy shore. They frequent the deep sea during severe weather for protection from the cold, by which they appear to be considerably influenced in their movements. Thus soles have been known to congregate in incredible numbers to a patch of water in the North Sea (30 to 40 fathoms deep in some parts), 60 miles east and west and from 6 to 10 miles wide, called the "outer silver pit." The severe cold had driven them into this deep water, and "the nets were hauled up bristling with fish trying to escape through the meshes, and such catches were made as the most experienced fisherman had never before dreamed of." (Holdsworth, 'Deep Sea

Fishing,' p. 95. This case happened several years ago, but since that event similar ones have occurred; the soles resorting to the deep silver pits in severe weather, and again dispersing on the appearance of warmer weather to shallow waters. The term "pit-season," is now well understood by the Grimsby fishermen. Where near the estuary of rivers, soles will run up for miles even above the tideway and remain there for months together, sometimes, it is asserted, shedding their spawn in the fresh water. Yarrell, quoting a letter from one who resided on the banks of the Arun, writes, "I succeeded yesterday in seeing the person who caught the sole about which you enquire, and who has been in the constant habit of trawling for them with a 10 feet beam trawl in this river for the last forty years. The season for taking them is from May to late November. They breed in the river Arun, frequenting it from the mouth four miles upwards, which is nearly to the town of Arundel, and remain in it the whole year, burying themselves in the sand during the cold months. The fisherman has occasionally taken them of large size, two lbs. weight each, but frequently of one pound; and they are thicker in proportion than the soles usually caught at sea—in other respects precisely the same; and it is evident that they breed in great numbers in the rivers, from the quantity of small ones about 2 inches long that are constantly brought on shore when drawing the net for grey mullet." ii. p. 349.

*Food of.*—Marine worms in large quantities, especially where the ground is sand mixed with mud; molluscs both univalve and bivalve, crustacea: I have found remains of razor shells (*Solen*), in quantities; also *Syndosmya alba*,
*me prismatica*, and other bivalves. *Cardium*
d that tempting-looking fat mass of molluscan
ine *aperta*, very common on muddy ground.

*Donax* and *Tellina* I have noticed. Young fish are doubtless also eaten by soles, remains of echinoderms as the "green-pea urchin," (*Echinocyamus pusillus*) have been noticed in their stomachs. A large proportion of sole food is supplied by the mud which they swallow whether directly or indirectly by the worms they eat. From some localities, as for instance at Pwllheli, the soles' stomachs are quite black from the contained mud, especially in the young fish, called "slips," whose small mouths are not suited for large objects. Mixed with this mud will be found minute organisms, the bristles or other remains of chætopodous annelids as *Arenicola, Nerine, Phyllodace, Nereis*; a large percentage of nourishing food is contained in the mud thus swallowed, as it contains much organic matter in the shape of minute vegetable and animal substances. The nourishing qualities of mud and sand may be inferred from the presence on the shore of the countless castings of the lug-worm (*Arenicola piscatorum*) so familiar to every sea-side visitor, which simply swallows the mud and sand, retains and assimilates the nutritive matter and ejects in those well-known little hillocks of sandy spiral coils the remainder. When soles frequent localities where sand alone, or for the most part, forms the bottom, the flesh is not so firm and the fish are thinner. The lemon sole (*Solea aurantiaca*, Günther) for instance is chiefly found in clean sand; and the comparative poorness of its flesh may, with good reason, be attributed, to a certain extent, to the absence of nutritive mud material.

*Spawning.*—The usual months are March, April and May, but the time may be sometimes earlier or later. The mode of deposition of spawn, has not, I believe, been witnessed. The sole is probably a surface spawner, like most, if not all, of the Pleuronectids. Mr. Epton in his essay on "The Migration of Spawning of Sea Fish suitable for Food," ('Fish and Fisheries,' p. 249), whilst fishing on the well, (North Sea), observed small bunches, or clusters of spawn, adhering to the warp, and on comparing these with the eggs of soles spawning at the time he concluded that these suspended clusters were soles' eggs. This, however, seems to me, very doubtful indeed. The same writer conjectures the size of about 2 to 4 inches in length for one year's growth; 5 to 9 inches at two years; and that no spawning occurs till four years old. He thinks the rate of growth is slow. The whole question, however, can be only settled by actual experiment. Buckland calculated about 134,000 eggs in a sole a pound in weight. Soles seem to come to our shores for the purpose of spawning, and do not generally spawn out in deep water or far from land, except in banks which are more or less shallow. The general reason for fish approaching our shores to spawn, we should attribute to the greater abundance of food near the coast than a great way from it, especially such minute forms of animal life as are suitable for the young fry of various fishes. Active surface fishes, as mackerel and herrings, would find abundance of minute food creatures far away from land near the surface throughout the summer months; but the young Pleuronectids being ground fishes, as a rule, would not meet with the same quantity of required food in deep water as they would in shallow water. For a short period of their lives, soon after being hatched, the young soles or other flat fish might indeed find abundant food in the countless millions of entomostracous crustacea, crab larvæ, &c., &c., that colour whole areas of the water, at the surface; but soon these infant fish cease to be surface swimmers, and assume the general ground habits of the adults; and there ore continuous supply of regular food in localities ks girt with a profusion of algæ, or where large quantities of organic matter in a comminuted condition pour themselves into the water from our large rivers and estuaries, than is to be found in the deeper seas, and, as I have already said, a very important element in sole food consists in the nutritive mud, which, generally speaking, would be found near in shore rather than at great distances from it. The sole attains the size of 20, 24, or even 26 inches, and may weigh as much as 5 lbs., 6 lbs., or 7 lbs. Casts of a pair of soles from Ireland which weighed together 12 pounds were in the Buckland Museum. Very fine soles are brought into Brixham and Plymouth by the Dartmouth (Torbay) trawlers daily throughout the year; and I must say a Brixham sole with its full deep body and shining ink-spotted pectoral fin is a sight on which a fisherman's eye loves to dwell, even æsthetically, apart from the pleasant anticipation of its value in the market.

*Modes of capture.* — Almost always by the trawl; occasionally soles are taken by hooks. The chief fishing station is Brixham, but there are good trawling grounds off the South coast from Sussex to Devonshire. Numbers of small soles, called "slips," are captured during the summer months by shrimpers in their nets and by inshore trawling and other ways. Great injury is by some persons supposed to be done in this way to the general supply, which it is thought is daily becoming shorter. The whole question is discussed in the *Introduction*. Few soles are caught in the North Sea, except at particular times, as during the "pit seasons" already mentioned. Whether there is an absolute scarcity of soles in the North Sea, which for some reason may be less suited to the production and increase of soles than places farther south, or whether, as appears to me to be far more probable, the enormous area of that sea, which is fished to a very limited extent, contains distributed throughout its length and breadth soles in great abundance, but which there are at present no adequate means of capturing—whatever be the real fact must remain undetermined. Torbay and its adjacent waters have been trawled over for years, and the area there is small indeed compared with that of the North Sea; but there is no diminution in the supply. Soles are erratic fish and do not "school" anything like to the same extent that plaice and haddock do; and the chances of meeting with them are therefore less than for these last-named fish. On making many enquiries at Brixham I was almost invariably told, in answer to my question "Do you catch fewer soles now, taking the whole year through, than formerly?" "No, sir, we catch as many as we used to do, and I do not think that they are diminishing at all; but you see, sir, we cannot always drop across them, and they are always wanted; there is such an enormous demand for them."

Soles are caught all the year round; but during the months of April, May, and June, they have not recovered from spawning, from which process nearly all fishes to some extent suffer for a time, and the flesh at that time is somewhat soft and watery.

*Quality of flesh.*—Perhaps one of the best of all the white-fleshed fishes that swim, of a beautiful white colour, firm, flaky, and of excellent flavour; the sole may be said to "head the poll" in competition as a food fish. But besides the excellence of the flesh, there are other considerations which cause it to be in such demand; it is easy of digestion and always recommended as the invalid's fish; it is readily and promptly cooked, so that travellers or other persons coming into an hotel, and wanting some
ner or tea prepared at once, can have their sole fried
few minutes; it permits itself to be cooked in

various ways and it is excellent in all; it is always supposed to be in season, consequently it is always in request.

*Commercial value.*—In this respect, of all the white-fleshed fish, the sole stands highest, often fetches a price per lb. as much as the pink-fleshed salmon, even when that fish is dear. A sole now-a-days at 1*s.* per lb. may be said to be cheap; 1*s.* 6*d.*, 2*s.*, or 2*s.* 6*d.*, is by no means a fabulous price. The wholesale price, of a box of soles at Grimsby market, varies from 80*s.* to 180*s.*, but much larger prices are sometimes given; thus on the 14th of March, 1883, a box brought 263*s.*, and even 2*s.* 6*d.* per lb. is quoted wholesale price at Grimsby about the same time. But it must not be supposed that the very high price paid wholesale at Grimsby is an actual sample of the price of soles at Billingsgate or Brixham. Soles are always dearer at Grimsby than perhaps anywhere else; the reason is that the North Sea trawlers do not catch many soles, and the market is very poorly supplied with the fish that these trawlers take; but as Grimsby has about the most important and extensive general fishing business in the whole kingdom (for it delivers north, south, east, and west for hundreds of miles), so the fish-traders there must have soles in order to supply the demands of their customers from all parts; consequently the competition for securing the all-important sole is vigorous, and at times almost unlimited as to price. On account of the high price which soles realise at Grimsby, supplies from Lowestoft and other places are despatched from the scene of their capture to flourishing Grimsby, and the prices realised are sufficient to defray the extra cost of railway carriage, and no doubt leave a comfortable share of profit as a marginal residue for the consignors.

*Names.*—The shape of the sole has supplied this fish with its names. Tongue-like, it suggested to the Greeks the name βούγλωττος, literally "ox-tongue," but as Rondelet says rather from its large size (βου- in composition having the sense of "greatness") than from any fancied resemblance to the tongue of an ox; compare our word ox-eye, "the great daisy." Of oblong flatness it also suggested the name of *solea* to the Latins, *i.e.* "the sole of the foot."

It cannot be doubted that βούγλωσσος and *solea* mean the sole. Archestratus (in Athenæus, vii. p. 288) speaks of the roughness of the *buglossus.* Ovid (Hal. 124) speaks of their flashing past when disturbed, "fulgentes solex candore." Dr. Badham rightly says that the trivial Greek name, the "ox-tongue," or simply "tongue-fish," names by which the sole is still recognised in Spain and Italy, would, in the absence of all other evidence, have left little doubt as to the identity of the two. Olympio, in the 'Carina' of Plautus (ii. 8, 62), asks whether he should bring some "tongue fish" (*lingulacas*) from the market, to which old Stalino replies, "Quid opus est, quando uxor domi est? Ea lingulaca est nobis, nam numquam tacet." Dr. Badham has cleverly rendered this as follow:

"'Fresh tongues for sale! Who'll buy, who'll buy?
Come, sir, will you?'—'No, friend, not I;
Of tongue enough at home I've got,
In my old wife, Dame Polyglot.'"

Fishermen use the term "tongues" or "slips," for young soles about 5 inches long. The tongue fish is a common name in the European languages, as *tungfisk,* Swedish; *tunge,* Danish; *tong,* Dutch; *tafod yr ych,* Welsh, "ox-tongue."

In John Russell's 'Boke of Nurture,' these fish are variously spelt *soles, soolis, soolus.* The French name Perdrix de mer, "partridge of the sea," on account of the excellency of the sole's flesh, is as old as the time of Belon (1553), who mentions it. The ordinary French word is like the English.

*General description.*—Height of the body about 3 in the total length; upper eye a little in advance of the lower; nostrils on the blind side very narrow. [In *S. aurantiaca* one of the nostrils is wide and circular, and fringed, and serves at a glance to diagnose light varieties of *S. vulgaris* from it.] Dorsal fin commences in front of the eye; both anal and dorsal fin-rays have a series of small scales; caudal fin rounded; gill-rakers rudimentary; colour dark brown, but lighter colours are not uncommon. Pectoral fin with a conspicuous dark or ink-black blotch. Lateral line straight. Reversed examples are not unfrequently met with, and piebald specimens are sometimes seen.

The lemon sole (*Solea aurantiaca*, Günther, *lascaris*, Day) is now and then seen in the markets, and is sold with the common sole. The fishermen call it the sand-sole, from its frequenting clean sandy bottoms. It is more of a deep-water species than the common one; the Brixham trawlers say it is not uncommon off the Channel Islands. It is a very prettily-coloured fish of a brownish pink, mottled with dark spots, or of an orange colour with black blotches The name of "nutmeg sole," sometimes used, is good and descriptive for the less orange-coloured specimens. The large circular fringed nostril on the blind side is a readily discerned character. I procured at Torquay, in October, two specimens, about 12 inches long, of the nutmeg colour. The fish, however, is rare and is not equal to the true sole as a fish for the table, and having no commercial importance may be dismissed without further consideration. The lemon sole (*solea*) must not be confounded with the so-called *lemon sole* of our fishermen and fishmongers, which, as already pointed out, is a dab, and belong's to the genus *Pleuronectes*.

### THE VARIEGATED SOLE (*Solea variegata*).

*Pleuronectes variegatus.*—Donovan, Brit. Fish. pl. 117.

*Monochir microchir.*—Cuv. Règn. An.

*Pleuronectes lingula.*—Pennant. Brit. Zool. iii. p. 313. E. H.'s MS.

*Solea lingula.*—Jenyns' Man. p. 468.

*Monochirus variegatus.*—Thompson, Nat. Hist. Irel. iv. p. 207; Yarrell, ii. p. 353.

*Solea variegata.*—Fleming, Brit. An. p. 197; Günther's Catal. iv. p. 469; Day, v. pt. 43, pl. 108, fig. 1.

*Red-back flounder.*—Hanmer in Pennant, Brit. Zool. iii. p. 313.

*Variegated sole.*—Yarrell (*l.c.*); Couch, iii. p. 203, pl. 177.

*Geographical distribution.* — The British coasts to the Mediterranean. This little fish appears to be rare northwards, and to occur more frequently as we proceed in a southerly direction; it is said, however, to be not uncommon in Yorkshire, rare off Scotland, and not often captured on the Irish coast, though several specimens were taken off Galway in 1848 (Day). It seems to be very common off the Devonshire coast; often seen in Plymouth market, and at Brixham. On trawling excursions I undertook in October, numbers of *S. variegata* and *S. minuta* were captured. The latter fish is too small for edible purposes.

*General habits.*—It seems to be resident around our southern shores throughout the year, approaching the land in the spring; but is a more decided inhabitant of the sea than the common sole, and is taken by the trawlers generally some way from the land. At present, however, little is known of its habits.

*Food of.*—Worms, small bivalve molluscs, and crustacea.

*Spawning.*—Nothing known. Usual size about 6 inches; it attains to a length of 9 inches.

*Mode of capture.*—By the trawl only.

*Quality of flesh.*—Excellent, firm and good flavoured. Some I had fried at Brixham, in October, I could not distinguish from the common sole which I had cooked with it and served on the same dish. Hanmer says that, "though there is some resemblance to the texture and flavour of the sole, it is inferior in richness and firmness of flesh."

It should always be fried.

*Commercial value.*—Of very little marketable value, but quite appreciated in Devonshire, where alone it is taken in any numbers. I saw numbers at Brixham and Plymouth in October; they are bought at a cheap rate, and consumed by the inhabitants. I found the retail price in the market at Plymouth to be about at the rate of four fish for sixpence; their size being about 7 inches. Thus four excellent fish for sixpence would be sufficient for two persons. Commercial value is not always a test of real worth. Mr. Dunn, in February, 1881, supplied Mr. Day with specimens, and informed him that these fish were being "taken near Plymouth in hundreds, averaging about six to the pound, and were being sold in pads separated from the other soles as offal."

Day saw thousands landed at Plymouth in August, 1881; they had been taken during at least the three previous months.

*Names.*—The *variegated sole*, from its colour, often of a rich chestnut brown with several distinct dark vertical bands on the body and fins. The ordinary name at Brixham and Plymouth is *thick backs.* At Weymouth it is called *bastard sole.*

*General description.*—The height of the body is a little more than 3 in the total length. None of the nostrils dilated; body very thick; eyes on the right side; dorsal fin commences on the snout. Pectorals of both sides small, but that on the blind side rudimentary, hence the proposed generic name of monochir (*μόνος* "one," *χείρ* "the hand"). Colour, reddish or chestnut brown clouded with dark cross-bands, more distinct in the dorsal and anal fins. Gill rather rudimentary. Lateral line straight. Scales thickly and acutely ciliated, and extending along the rays of the fin.

There is another British species of sole, the *Solea minuta* (Günther), or the solonette, which the trawlers in Devonshire catch in large quantities; they are too small for the market, and are with the rest of the "rubbish" thrown back into the sea. They are usually about 4 or 5 inches in length, and are pretty little fish.

## FAMILY *Clupeidæ.*

"Body covered with scales; head naked; barbels none. Abdomen frequently compressed into a serrated edge. Margin of the upper jaw formed by the intermaxillaries mesially; and by the maxillaries laterally; maxillaries composed of three, sometimes moveable pieces. Opercular apparatus complete. Adipose fin none. Dorsal not elongate, and sometimes very long. Stomach with a blind sac; pyloric appendages numerous. Gill apparatus much developed, the gill openings being generally very wide. Pseudo-branchiæ large, except in *Megalops.* Air-bladder more or less simple. Inhabitants of all seas, many species entering fresh waters." (Günther, Catal. vii. p. 381.) The only two marine genera belonging to the family of clupeidæ, which occur on our coasts are *Clupea* and *Engranlis*, the former containing the herring, the sprat, and the pilchard, the latter the anchovy; but as this last-named fish is only occasionally taken on the southern coast of England, and has, at present at all events, no commercial value, it will be necessary only to notice the fishes of the genus *Clupea*, which is thus characterised by Dr. Günther.

GENUS *Clupea*.—" Body compressed, with the abdominal serrature extending forwards into the thoracic region. Scales of moderate or large, rarely of small size. Upper jaw not projecting beyond the lower. Cleft of the mouth of moderate width; teeth, if present, rudimentary and deciduous. Anal fin of moderate extent, with less than thirty rays; dorsal fin opposite to the ventrals. Caudal forked. Inhabitants of the coasts of every part of the globe, many species entering fresh waters." (Catal. vii. p. 412).

### THE HERRING (*Clupea harengus*).

*Harengus*.—Rondelet, de Pisc. p. 222; Gesner, p. 408; Willughby, p. 219, Tab. P. 1, fig. 2.

*Clupea*.—Artedi, Spec. Pisc. p. 14, 15; Gen. p. 7, No. 1; Syn. p. 31.

*Clupea harengus*.—Lin. Syst. Nat. i. p. 522; Lacép. v. p. 427; Fleming, Brit. An. p. 182; Jenyns' Man. p. 434; Yarrell, ii. p. 183; Parnell, Fish. F. of F. p. 155, tab. 35; Kröger, Dan. Fisk. iii. p. 139; Cuv. and Valenc. xx. pp. 30–242, pls. 591, 592; Nilss. Skand. Faun. Fisk. p. 491; Günther, Catal. vii. p. 415.

*Clupea leachii* (var.).—Yarrell, Brit. Fish. ii. p. 193; Couch, iv. p. 107.

*Common herring.*—Pennant, Brit. Zool. iii. p. 444, pl. 79, 2.

*Herring.*—Couch, iv. p. 95, pl. 202; Yarrell, &c.

*Geographical distribution.*—The north Atlantic, from N. Lat. 69° to N. Lat. 47°, and the northern shores of Asia. Shoals of herrings are found in Iceland, at Faröe, Norway, Sweden, Denmark, the Baltic, Holland, and as far south (but not in any considerable numbers), off the coast of France, as the mouth of the Loire, beyond which they do not seem to extend. They do not occur in the Mediterranean. They are found in various parts of Asia, as in the Black and Caspian Seas, Okhotsk, Kamtchatka, in the Bay of Avatska on the south-east coast of Kamtchatka, on the north-east coast of Siberia, as in the river Kolyma, Lat. 69° 28′, Long. 168° 28′, which they ascend in great shoals, and where they are important food to the natives; they occur in Behring's Straits, Bathurst inlet, etc. They are found on the Atlantic coasts of North America. Thus it will be seen that their geographical range is very extensive. On the British coasts they occur often in extraordinary multitudes, Scotland generally supplying the largest and best. It is not deemed necessary to mention the various parts of our coast which are visited by these most valuable of all fishes under this heading; such places will be considered in relation to their

*General habits.*—Although much attention has now for several years been bestowed on the Natural History of the herring, there are many questions which still await a satisfactory answer. At one time it was supposed that the herrings' home was in the cold regions of the Polar Seas, and that from thence the mighty shoals dispersed themselves in a southerly direction to other seas, during the summer and winter, visiting our coasts, and returning northward to their Arctic winter quarters. Who first originated this Arctic theory of navigation I know not; I find no notice of anything of the kind in Rondelet, Gesner, Ray, and Willughby. Pennant's name is specially associated with this theory, which he implicitly believed in; but whether it had been held before Pennant's time (born 1726) I have not been able to discover. However, it was the current belief for some years after Pennant's time. Mr. George Sim in his 'Essay on the Natural History of the Herring,' with special reference to its migration, etc. ('Fish and Fisheries Prize Essays,' p. 49, 1883), remarks that "it is surprising that a man of such close observing powers as Pennant should not have seen the mistake he makes," etc.; but a greater than Pennant, even the illustrious Cuvier, believed in a North Sea migration. He says, "Ce poisson fameux part tous les ans, en été, des mers du nord, descend en automne sur les côtes occidentales de la France en légions innombrables" (Règne Anim. ii. p. 318). No wonder then that the Polar Sea theory held its ground for many years. It is now well known that herrings are to be found all round our coasts throughout the year, now in shallow water, now retiring into deep water—not at stated definite periods, but irregularly, generally after spawning time, which is itself very irregular, some herrings spawning at one time, others at another. The objection of Yarrell and Mitchell, that herrings are not found in any numbers in icy seas, is not valid. In Kamtchatka and north-eastern Siberia and Iceland, herrings are sometimes very abundant. The Iceland fisheries are likely to prove a great success. Enormous quantities of herrings have been taken, chiefly in the Sejdlis Fiörd; but it is only lately that a fishery has been established here on any important scale. Icy seas are not destitute of herrings.

As was said just now, much remains to be explained with respect to the habits of the herring. All fish are to some extent apparently capricious in their movements; the herring has the character for being eminent in this particular. It appears in a certain locality in prodigious numbers for a period of years more or less definite; and then without any apparent reason it abandons that place—to return to it again, perhaps after a time. Upon these migrations the most important fishery perhaps almost in the whole world, certainly to ourselves and the north of Europe, depends. The question, therefore, "What influences these fish in their wanderings and brings them within reach of our apparatus for catching them?" is a most interesting and important one. Let us see what facts in their life history are clearly known. We know that—

1. Herrings are inhabitants of our waters throughout the year.

2. That they frequent the neighbourhood of our shores in countless numbers at certain periods of the year.

3. That these visitations are generally more or less periodic for each locality.

4. That the time of their appearance in large shoals varies at different parts of our coast.

5. That they appear earlier in the year on our northern coasts, and gradually later as we proceed southwards.

6. That the spawn is deposited in cemented masses on weeds or stones, or other objects at the bottom of the water.

7. That the ovaries and milt arrive at maturity at very different times; some fish having full spawn at one time, others at another time.

8. That there are two principal spawning seasons for the ajority of the shoals, which are (1) the spring, and (2) the mn.

9. That although these are the chief spawning times, there is no actual intervening period when no herrings spawn.

10. That after spawning the herrings leave the immediate shores and generally retire into deeper water, which may not be very far from the land.

11. That during the time of spawning they do not, as a rule, take any food.

12. That young herrings of 1¾ to 2½ inches long ("Sile") are cast on the shore (Aberdeen and Kincardine) in the month of January, and are found in rock-pools in June and July of about the same size. (Mr. Sim, 'Fish and Fisheries,' p. 46.)

13. That these young herrings ("Sile") pass their early life near the shore, sheltering amid algæ and rock-pools, where such exist.

14. That herrings after spawning eat voraciously and get very fat, laying up stores of adipose matter for the gradual development of milt and ova again.

15. That the autumn-captured fish are, as a rule, finer and better than the spring fish.

16. That herrings are to a great extent surface-swimmers, especially during the night; but that they also frequent the bottom, which is proved by their depositing their ova there, and by the fact that they are often found in the stomachs of cod and other ground-feeders.

On carefully considering the whole question of the cause of herring migration coastwards, I think there can be little doubt that the reproductive instinct is the chief factor in the problem. There may, however, be some doubt; because though we are certain that herrings deposit their spawn in water near our shores which is comparatively shallow, we are not in a position to affirm that they never deposit their spawn some distance from land, in the open sea. We have, however, no actual proof that this ever happens. There

are apparently only three principal and urgent motives which can influence fishes in their voluntary movements from one place to another, and these are (*a*) the desire for food, (*b*) the spawning or reproductive instinct, and (*c*) the temperature of the water. In most of our sea fishes the search for food is the dominant and most urgent nature-call. That the search for an abundant supply of food should influence the movements of fishes is in the highest degree probable, on *à priori* reasons; for if we eliminate, from the life history of fishes all such possible or probable influences which may be supposed to, or which actually do, to a certain extent, direct their wanderings, we cannot eliminate from their habits the desire for abundant food, upon which the very existence of sea fishes, more perhaps than of any other group of cold-blooded vertebrates, depends. Sea fishes, unlike some of our fresh-water species, as the *Cyprinidæ*, are incapable of a prolonged fast; they must nearly always be eating, and when abundant food is not obtainable in one locality they move to another. But the spawning instinct is also a most powerful determining agent in the movements of certain fishes, as in the well-known instance of the fasting salmon, which will ascend rivers for miles and overcome all possible obstacles in order to arrive at its desired haven for depositing its ova. The periodic ascents by the salmon of our rivers are solely guided by the reproductive instinct. Its movements from salt water to fresh are certainly not caused by the search for food. Another law in its nature, equally imperative, impels
to exchange salt water for fresh. During its
sh water it scarcely ever feeds; it may
wallow a worm or small fish, or other aquatic
know it is tempted to rise at the gaudy
angler; but you will search in vain for

any indication of food in the stomachs, or the whole intestinal tracts, of ninety-nine out of every hundred salmon you may examine, if the fish have been any time in the river. But in the sea the salmon feeds voraciously. I have often taken four or five good-sized herrings out of the stomach of a sea-dwelling fish; but have never seen any indications of food in a fresh-water inhabitant. The salmon leaves the sea a fat fish, and the fresh water a very lean one. The case of the herring seems to me to be, to a considerable extent, analogous with that of the salmon. The food-searching instinct is not the principal cause of the herring's visit to our shores. The reproductive impulse is the main agent. That the desire for food is not the main cause is proved by the absence of food in the stomachs of full herrings, that is, of herrings which are ready to spawn. As to the condition of the stomachs of the numerous fish which I have examined from different parts of our coasts at different seasons of the year, I find it recorded invariably (with one single exception) in my note-book, "Nothing or next to nothing in the stomach and intestines." Of course as the food of the herring consists in a great measure of small creatures such as entomostracous crustacea, I had constant recourse to the microscope, which, however, revealed no remains of food. Other observers have also recorded the absence of food in full herrings. In a work prepared by W. Von Wright, of Stockholm, and published by order of the king of Sweden in 1843, 'On the Herring and the causes of its scarcity on the Swedish coast,' he says, "I generally found the greatest quantity of food in the young herrings, and the least in those having large milts or roes. From this circumstance, along with the fact that the herring is very lean after spawning, I have concluded that the full herrings do not come to the coasts for the purpose of seeking food, but for the purpose of spawning" (Mitchell, 'The Herring, its Natural History and its Importance,' pp. 51, 52). The late Mr. Mitchell's own account is to the same effect:—"Those fish which had the milt or roe small had their stomachs full of young sand eels about two inches long; whilst those in which the milt and roe were full had none" (p. 48). Similarly Prof. Huxley:—"There is usually no food in the stomach of a herring which approaches [sexual] maturity." I am aware that in some parts of Scotland herrings are sometimes taken with hook and line while they are on the spawning ground, but this exceptional taking of a bait does not invalidate the general rule of the herring's abstinence from food while in its full state, any more than the occasional rise at the artificial fly or the occasional capture by a hook baited with a worm invalidates the proved rule of the salmon's abstinence when, bent on spawning, it ascends our rivers. This abstinence from food of the full herrings is denied by Mr. George Sim (Prize Essay, 'Fish and Fisheries,' p. 48). He wishes to point out that "it is no general law that full herrings are to be found with no food in their stomachs," because, as he adds, "I have examined these fish with milt and roe full grown, and have found their stomachs crammed full of two species of crustacea, viz. *Hyperia galba* and *Mysis spiritus*, while there were many others with milt and roe in a very backward condition with nothing in the stomach at all." May not, however, the general law of abstinence hold good, and Mr. Sim's instances be exceptions to that law?*

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* Axel Ljungman ('Contributions towards a more correct knowledge of the Herring's mode of life,' in Report U. S. Commission for 1879, p. 505) says, "As in many places herrings are principally caught during the spawning season, *when, as is well known, they do not eat much*, the idea has, especially in former times, been quite prevalent among fishermen that the herring lived on nothing else but water."

The movements of the herring shoals from one place to another may be considered as of two kinds. First, there are general wanderings, either in shoals or not closely compacted, for the sake of food. Secondly, special migrations shorewards for the purpose of spawning. Mr. William Watt (in his thoughtful and admirable essay 'Fish and Fisheries,' p. 59) concludes "that food is one of the main agencies influencing the movements of the herring; though the assembling of the great shoals seems primarily due to the reproductive impulse." He rightly recognises these two kinds of movement as the general progress shorewards, and minor deflections in their course. The shoals of the fish assembling for their spawning migration are formed at the surface of the water, when the fish are in the *mattie* stage, and in this state they remain together till after the shedding of the spawn. Mr. Watt regards this, rightly I believe, as a manifestation of their reproductive instinct. "At all periods of its existence, even in its very earliest days, the herring is gregarious in its habits; but the huge and compact collections to be met with, first as 'matties' and then as full spawned fish, do not remain permanently concentrated together in such extreme fashion. After the accomplishment of the great function of their nature, they begin to separate. The 'spents' of the end of the fishing season are not found in the dense masses of the earlier shoals, but in flocks more or less spread out. The food problem has now become serious. The shoals were content to fast, but the emaciated 'spents' or 'shotten' herrings are so ravenous with hunger that they do not spare even the spawn and young of their own kind. Their excessive sociability now vanishes, and instead of crowding together, they begin to look after their prey with great keenness, and to spread themselves over a wide area of sea—most probably without regard to locality or special order in their movements. Some remain near the shore; but the great mass appear to wander indefinitely through the sea. Food is now the dominating idea and sole aim of the herring—to find food for itself and to avoid becoming the food of some larger fish" (p. 56). This I believe to be the true state of the case, and to explain the opposite statements with regard to herrings' movements, some people asserting that they are not of the nature of true migration, but merely fortuitous wanderings after food; others that the movements are true migrations shorewards for the purpose of spawning. The movements are both; general, more or less fortuitous, and without destined purpose except as relates to the acquisition of food, and special shorewards for spawning.

I do not mean to assert that the food element has nothing whatever to do with the special shorewards migration, at the time when the shoals of "matties" are assembling and meditating movement, at an early period of their shoreward journey and doubtless for some time after the army is on its march, herrings are feeding. Those "matties" whose ovaries and milt were more advanced in development than others would, very likely, be the first to feel the instinctive migrating impulse, and would lead the way, at first perhaps wandering circuitously in search of food, but still with the spawning instinct in view, which would become stronger and stronger as the ovaries and milt were reaching maturity. Herrings being pre-eminently gregarious the less matured "matties" would join in the movement forward and follow their leaders; and this would, I imagine, xplain why not only full herrings but "matties" and quite ll herrings are found to migrate shorewards. "Matties" va and milt but slightly developed must certainly require large quantities of food, otherwise they could not mature their sexual organs ; and it is probably that for some weeks they continue to feed, gradually however abstaining from food as these organs get nearly ripe, intent then only on securing a suitable shore for spawning. At first, and for some time probably, their movements would be in that direction where food would be most abundantly found ; if such an abundance lay in the direction of land they would steer shoreways, if away from land they would probably direct their course thitherwards, and this consideration may to some extent account for the uncertainty of their arrivals at particular places. The shoals have steered in the direction which seemed to promise abundant food. In the spring and summer months herrings would certainly find abundant surface or ground food in the open sea sixty or seventy miles from land, as I myself witnessed last summer when trawling in the North Sea. The surface tow-net brought up innumerable quantities of crab larvæ (*zoea*) and entomostraca ; small medusæ, and that curious abnormal creature the *sagitta*. Herrings are chiefly surface feeders, and crustacea form the greatest proportion of their diet. Towards the autumn, however, this profusion of surface life ceases to exist, the minute organisms have been diminished by having been eaten, or have subsided into deeper water, and though even late in the year immense quantities of some of the entomostraca may be found far out at sea, there is no longer that incalculable wealth of herring food that there was during the summer months. In the autumn and winter, however, there would be comparative scarcity of this minute food, be it the ova and fry of other fishes, or the small swimming crustacea, or floating algæ, out many miles from land ; but at this time nearer shore, where rocks

are covered with a profusion of algal growth, and where large rivers pour forth abundant mud often teeming with living organisms, herrings would meet with just that kind of microscopic food which the little mouth and stomach of the young fry could seize and assimilate. It must be remembered that newly-born fish, after the absorption of the vitelline umbilical sac, require a copious supply of some nutritive matter, and such suitable food must be excessively minute and microscopic. The stomachs of young herrings about two inches in length I have found to be full of minute entomostraca mixed with particles of mud containing diatomaceæ and other organisms. Were the young autumnal or winter progeny to find themselves far out at sea at that time, they would not easily find the required surface food. Hence we can, I think, see the reason for herrings choosing to deposit their spawn near the shore, at the mouths of rivers, and even occasionally at some distance up the rivers. It seems fair to conclude that, as the herring spawns at the bottom of the water near the shore, some conditions favourable to the development of the ova are secured by the deposition of the egg-clusters there, which they would not meet with were the eggs deposited at the bottom of a sea many fathoms deep. What the conditions may be which are necessary for the healthy development of the ova of fishes one cannot positively affirm: it is probable that a condition necessary for the development of one fish differs from one necessary for another; we cannot say whether herring ova deposited in water many fathoms deep would or would
velop; it would be desirable to institute experi-
on the ova of fishes placed at various depths.
of the pilchard, there seems to be no reasonable
on the surface of the sea, and it is curious to

note the marked difference in this respect between the herring and another clupeoid to which it is so nearly related. If many of our sea fishes spawn at the surface—a proved fact—it seems certain that at the surface they meet with the exact conditions required for the development of the ova; these conditions would seem to point to the influence of light and air which submerged eggs would meet with better in shallow water than in deep. The spawning of the pilchard, though different as to the deposition of the ova, is in one respect analogous to that of the herring, and seems in a measure to corroborate the view I have expressed, that one motive for the herring seeking shallow water for the egg-deposit is to secure suitable food for the young fry. Pilchard spawn in spring and autumn; according to Couch the spring ova are shed far away from the land, the autumn ova nearer to the shore. Here again the young pilchards, far from land in the spring and summer months, would find abundant suitable surface food in the birth swarms of crustacea and floating algoid products, especially *diatomaceæ*, themselves teeming with infusoria,—I may mention that *diatomaceæ* enter largely into pilchards' diet, as I have proved by the examination of many stomachs and intestines—while the young fry of autumn and winter would get such food as they require more readily and abundantly near the shores. To sum up what I have stated, I believe that the main impulsive agent in the herring's shoreward migration is the reproductive instinct, and that the food instinct, though at first more or less decided, becomes as the sexual organs arrive at maturity quite subordinate, and that the reason why shore waters are chosen for the deposition of the egg-masses is because the shallower water presents the best conditions for their development, and the vicinity of land the best food-producing area for the young fry.

The temperature and condition of the atmosphere, state of the weather, storms and currents doubtless influence herrings as other fish, and occasion changes in the times of their appearance near the coast. On this subject I will make a few remarks by-and-by.

The nature of the ground has an effect of considerable importance on the presence or absence of herrings within a given area. Wherever the bottom consists of slimy argillaceous clay there is an absence of all marine organic life whether animal or vegetable. The herring receives both direct and indirect supplies of food from the nutritive matter which the water holds in suspension, and animal life depends on the presence of vegetable life to a very great extent, so that in clay or shifting sand in which no plant can take root, there will be a corresponding absence of animal life. The importance of the vegetable kingdom in supplying nutritive material to the creatures of the sea is thus well illustrated by Professor K. Möbius in the case of the Baltic and North Sea. "Large meadows of green seaweeds extend in the shallow waters near the coast wherever the bottom does not consist of shifting sand, on which no plant can take root. Wherever the bottom is stony, brown algæ (*fucoids*) grow, and further away from the coast, at depths of 60 to 80 feet, the bottom is in many places covered with red algæ (*florids*). At a still greater depth there are few or no plants; but aquatic plants torn loose from the places where they grow are often brought up in dredges from a depth of several hundred yards. After the gases filling their tissues have escaped, such plants sink towards the bottom, fall to pieces, and finally form the principal component part of the mass of dark soft mud forming the bottom of many bays of the Baltic and North Sea. When such mud, brought up in dredges, is put into a barrel, it does not appear to contain any animal life, but if it be put through a fine wire sieve, which cleans out all the mud, a large number of diminutive molluscs, worms, crustaceans, and other marine animals, may be seen. If we could dive down to the mud bottom without touching its surface, we would find it full of worms, shells, and other marine animals protruding from the mud, all busy absorbing with their mouths the particles of mud nearest to them ; and we would also see flounders, cod-fish, eels and other fish, digging themselves into the soft mud for the purpose of devouring its inhabitants.

"In the great depths of the Baltic, 90 to 95 fathoms, east of the island of Gottland, where the bottom consists of plastic clay containing but very few organic substances, I found very few worms during the summer of 1871. In the greatest depths of the Mediterranean, south-east of Sicily (1700 fathoms), where the bottom consists of yellowish clay, the British exploring expedition of 1870 found no traces of animal life. In the southern part of the North Sea, the muddy bottoms at a depth of 20 to 25 fathoms are literally alive with small crustaceans, worms, snails, molluscs, echinoderms and polyps, and are therefore rich in fish. Enormous masses of dark mud formed from vegetable matter which has sunk to the bottom of the deep fiords of Norway, furnish excellent food for their numerous fish and other marine animals. Besides the seaweeds, which in all latitudes grow at a depth of 25 fathoms on level bottoms, the sea produces different kinds of floating algæ which furnish food to marine animals." After mentioning the ubiquity of the diatomaceæ, which are found in every sea, the floating microscopic red algæ (*Trichodesmium erythræum*) of the Red Sea, Atlantic and Pacific Oceans, which cover the sea for miles and miles, the well-known fathoms had vast [illegible] (*[illegible] [illegible]*). Professor Möbius goes on to say: "Plants growing on and likewise furnish food for the animals of the sea. [illegible] carry many organic matter into the sea, which, with the fine mineral substances of the river water, sink to the bottom near the mouths of the rivers and form layers of thin mud. . . . At the greatest depths of the ocean, below 300 fathoms, both the number of species of animals and individuals decrease, evidently because the quantity of food is smaller." ("The Food of Marine Animals," U. S. Commissioner's Report, 1871, pp. [illegible].) The great abundance of animal and vegetable life near the coast influences the movements of all fish in that direction; but it is the young fish of not only the herring but of numerous other sea fishes that especially are benefited by passing their early days in shore nurseries, where minute food is abundantly provided for them. A bottom of plastic clay would certainly not suit herrings, and if in their wanderings they arrived at an extensive area of water which rested on such a bottom, we may be sure that the great army would hasten away from such a barren locality. The herrings feed very largely [illegible] more than any other fish on small crustacea, among which the copepoda form a very considerable portion of their food. Dr. Brady, speaking of the abundance in our seas of various kinds of the non-parasitic copepoda, says: "The bed of the sea down to the extreme depths attainable round the British Isles is inhabited by numerous copepoda; on sandy bottoms the most abundant species are *Longipedia coronata*, [illegible], and *[illegible] spinipes*." Brady; but *copepoda* of some kind are found in greater or less abundance on all sorts of bottoms. One exception must be made to this statement: in [illegible] hauls from a bottom of slimy, argillaceous mud, the product of the *débris* of disintegrating felspar rocks, taken from a depression of the depth of 15 to 25 fathoms at the north end of Mulroy Lough, county Donegal, Mr. Robertson and myself could not detect one trace of life of any kind" ('British Copepoda,' Introd. p. 9, Ray Soc. 1878). So that the absence of herrings from a given area may be due to the geological formation of the district bordering that area. The herring depends on animal food; the animal food depends on the presence of vegetable growth;* the vegetable growth upon the nature of the ground, and that on the composition of the adjacent coast.

So far the above remarks refer to the ordinary movements of the herring shoals, and the probable motives which prompt and direct those movements, at more or less stated periods throughout the year. But there is another problem which presents itself involving far greater difficulties than the former one—I mean the visits of herring shoals to certain localities, continued more or less in great numbers, for a period of years, and their absence again from those localities for a period of years. All sorts of explanations, some extremely foolish and childish, have been given for these visits and absences, as (1) that the herrings left the coast as a punishment from God because of the wickedness of mankind fishing on a Sunday, &c.; or (2) it was supposed that they were driven away, being scared by excessive fishing, by destroying the spawn, by noises, by leaving dead herrings at the bottom of the sea, by preventing the shoals reaching their spawning places, &c. Under the third head come reasons more or less probable, as that the fish were destroyed by unfavourable weather, by want of food, by unusual numbers of destructive natural agencies as predaceous fishes and birds; or it has been suggested that changes in the physical condition of the coast both meteorological and hydrological, accidental or periodic, have caused the herrings to leave their once frequented localities and to seek fresh pastures elsewhere. In a paper by Ljungman entitled 'A Contribution towards Solving the Question of the Secular Periodicity of the Great Herring Fisheries' (Copenhagen, 1880), of which Mr. Herman Jacobson has given a translation in the United States Commissioners' Report for 1879, p. 497, the author discusses the question whether there is really any secular periodicity in nature sufficiently strong to cause the disappearance of the herrings from certain coasts. He refers to the periodic returns of the solar spots which were proved to take place by the astronomer S. H. Schwabe, of Dessau, in 1843, and to the correspondence in the occurrence of northern lights and the changes in the solar-spot periods, as shown by Fritz in 1862, and by Köppen in 1873. "Thus evidence," he says, "was constantly accumulating to prove the great influence which the solar spots exercise on our earth." M. Axel Ljungman next endeavours to discover whether the solar-spot periods bear any relation in time to the Bohuslän herring-fishery periods, and he remarks, "we shall find that there is such a remarkable correspondence between the two that it can scarcely be considered accidental." He considers that Wolff, Fritz and others have conclusively proved that there are long solar-spot periods comprising about fifty-five and a half years. I will now quote M. Ljungman's own words. "Starting from the last of the above-mentioned fifty-five and one half years' periods, viz. the one extending between the minima of solar spots, 1810–1867, we will give a series of fifty-five and one half years' periods, and with each of these we will mention briefly whatever is known regarding the 'genuine sea-herrings'' periodical occurrence on the coast of Bohuslän, and when we have no data whatever we will mention such occurrences as can possibly be supposed to have some connection with the herrings' periodical occurrence, for from the time previous to the year 1300 we have scarcely any information regarding our Bohuslän herring fisheries.

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* This statement is perhaps only true in a general sense. We know practically that so far as littoral and pelagic forms of life are concerned, they are to a large extent dependent for their food not necessary directly, but indirectly, on plant-growth of some kind or other. The researches of the *Challenger* expedition, however, have resulted in the discovery of deep-sea forms of animal life at depths where light, indispensable to plant-growth, cannot penetrate, and where, in consequence, no plants can exist. It is probable that at a depth of 200 fathoms plants in a living state are entirely absent. But the bottom of the dark abyssal sea is full of animal life. If then there is an entire absence of living plants, the deep sea animals must get their food from such plants as, in the great Sargosso sea, may die and sink to the bottom, or, failing this, they must derive their sole food from that which is of an animal nature. The smaller and little-differentiated forms of animal life, such as the Protozoa—rhizopods and sponges—would supply food for those more highly organised. But whence do the *Protozoa* derive nourishment? The sea is full of creatures which are constantly dying and decaying, and the water at all depths holds these dead particles of animal matter in solution and suspension. And as the creatures in the dark abysses belong chiefly to the subkingdom *Protozoa*, they are able to absorb nourishment thus held in solution in almost infinitesimally small particles through the entire substance of their jelly-like, plastic bodies.

"1867–1922. Rich fisheries began in 1877.

"1811–1866. No good fisheries.

"1755–1810. Rich fisheries 1748–1808, which, especially during the last quarter of the eighteenth century, assume enormous dimensions.

"1699–1754. No specially good fisheries till near the end of the period from 1747 or 1748.

"1643–1698. Good fisheries, at least between 1660–1680.

"1587–1642. No good fisheries.

"1531–1586. Particularly good fisheries, at least between 1556 and 1587.

"1475–1530. No good fisheries.

"1419–1474. Good fisheries, at least about the middle of the century.

"1363–1418. No good fisheries.

"1307–1361. Particularly good fisheries, at least during the first thirty years of the century, which probably already commenced towards the end of the preceding century.

"1251–1306. At the beginning and about the middle of the period no good herring fisheries, although probably the fisheries were good towards the end.

"1195–1250. Probably there were good fisheries, judging from the fact that during this period Gullholmen, Öckerö, and other desert islands were colonised, and the convents of Marstrand and Dragsmark were founded.

"1139–1194.

"1083–1138. Probably there were good fisheries, during which Konungahella became the most important commercial city of the North.

"1027–1082.

"971–1026. Good fisheries, at least during the reign of Olaf the Saint.

"915–970. No good fisheries, at least during the beginning of the reign of Gunhild's sons.

"859–914.

"From this series of fifty five and a half years' periods, it will be seen, first, that large numbers of sea herrings came to the coast of Bohuslän during every other one of these periods, producing good fisheries and consequent wealth; second, that unusually good fishery periods ged about with less good ones. Thus the herring during the fifteenth and seventeenth centuries were far less important, and probably did not last as long as those of the fourteenth, sixteenth and eighteenth centuries. The Bohuslän herring fishery cycles seem therefore to correspond exactly with Professor Fritz's great northern lights' period of about two hundred and twenty-five years each, and to include one very good and one less good fishery period, as well as two intermediate periods when the sea herrings staid away from the coast. . . . It is also a strange phenomenon that the most flourishing fisheries of the herring-fishing period coincide with or occur about the same time with the liveliest formation of solar spots and the most numerous northern lights during a fifty-five and a half years' period ; and that a peculiar change took place in the relation between the solar spots and the temperature during the last decade of the eighteenth century, when Bohuslän, as is well known, had the richest herring-fisheries which have ever occurred. As there are also traces of such a change during the latter part of the seventeenth century, it is not impossible that such a change always coincides with the frequent occurrence of the sea herrings on the coast of Bohuslän" (pp. 500–502).

Summing up M. Ljungman's remarks, it may be said that the solar spots are periodic in their occurrence, and that their periodic occurrences comprise about 55½ years ; that the good herring fisheries are also periodic for about the same time ; that the maxima solar spots are coincident with good fisheries, and the minima with bad ones. In what way, however, it must be asked, is a coincidence between such vastly different phenomena as the solar spots (and northern lights) and the herring-fisheries, brought about ? How can there be any connection of the one phenomenon with the other ? A probable explanation points to the influence of the weather and the sea currents by the solar spots ; this may be expressed best in a quasi-syllogistical form as follows.

There is a coincidence in periodic occurrence between solar spots and northern lights—

The solar spots and northern lights influence the weather,

The weather influences the sea currents,

The sea currents influence the herring food,

The herring food influences the herring migrations.

M. Ljungman does not pretend to have answered this secular periodicity of the great herring fisheries satisfactorily. What he has advanced he confesses is only a theory. He promises to collect more material and to give fuller information on this interesting subject. His theory, which seems to contain a probable explanation, is certainly deserving of attention and further investigation.

I have already mentioned that a very important phenomenon in the movements of herrings is to be found in the atmosphere; added to this is the nature of the coasts and the sea bottom. As the question bears on M. Ljungman's theory, it will be convenient to state it now. Scientific literature bearing on this subject owes a debt of gratitude to H. A. Meyer, K. Möbius, G. Karsten and V. Hensen, who formed a ministerial commission for the scientific examination of the German waters, and have given us extremely valuable papers on (A) "The Physical Condition of the Baltic and the North Sea;" on (B) "Scientific Investigations upon the Fishes profitable to the Fisheries;" and (C) on "The Spawning Process of Salt Water Fish and its Importance to Fishermen." Popular tracts from these investigations of the commission have translated by Herman Jacobson, to whom also we are indebted for several translations from writings in the Norwegian and Swedish languages which treat of fish and fisheries, published in the United States Commissioners' Report, Washington, 1882, for a copy of which I have to thank Professor Baird, of Washington, the well-known commissioner who has done so much for the fishery interest in America.

G. Karsten states that there are three conditions of the sea water which exercise a decided influence on animal and vegetable life, and these are (1) temperature, (2) saltness, (3) currents; and that all three are influenced by the atmosphere and the nature of the bottom; that the condition of the water of the Baltic and the North Sea in their varying connection with the ocean, and the varying quantity of fresh water which they receive from streams and rivers, is another important fact to bear in mind. Now it is a well-known fact, that herrings appear off our coasts earlier in the north than in the south of the North Sea; that the first northern appearances gradually follow as we proceed southwards. Thus in the Orkneys fishing may begin in May; in the Firth of Forth the great herring fishery is carried on from July to September; at Yarmouth and Lowestoft from September to the end of November; in the Channel it is later still. As a general rule the herrings in the north are "full" at the end of August and September, while those caught at Yarmouth are not ready to spawn till October and November.

One would have been inclined to suppose that herrings would mature their ova earlier in the south than in the north, but the converse of this is the case; one would, perhaps, have been inclined to think that the southern waters would always be warmer than those of the north, and that, as a warm temperature tends to mature and a cold one to retard the development of the ova, the southern spawners would precede the northern spawners. What may be the reason for this apparent paradox? We must bear in mind that the temperature of the atmosphere is not always in all waters an actual and immediate index of the temperature of those waters. Much depends on the depth of water; its degree of saltness, which will mainly depend on the quantity of fresh water the sea may receive from streams and rivers, these latter being dependent for their supplies on the quantity of rain that falls, and especially on the melted snow from high lands at certain periods of the year; much depends on the currents. Now, confining our attention to the North Sea, we find that the quality of the water is by no means uniform throughout it. Karsten has the following remarks on the conditions of the North Sea: "In the North Sea three parts may be distinguished by their different depth. *First*, the southern and shallowest part, with a depth of about 35 meters, connected with the ocean by the narrow English Channel. To this part belong the Doggerbank and the coast waters of the Schleswig-Holstein and Jutland coasts. *Second*, the central part, extending northwards as far as a line drawn from Peterhead, in Scotland, to Cape Skagen (Jutland), with a depth of about 100 meters. *Third*, the northern part, with much greater depths. This last-mentioned part has free communication with the Northern Atlantic. All these parts meet in the Skagerrack, and through its waters are connected with the Baltic. . . . The southern part of the North Sea resembles the Baltic; it is shallow, and its nearest communication with the ocean is a narrow channel. In this part of the North Sea the temperature of the water, like that of the Baltic, is controlled by the temperature of the air. The only perceptible differences are caused by the influx of warm water from southern latitudes through the channel, and by water from the rivers Weser and Elbe, as well as by water from the Baltic, varying in its temperature according to the seasons, entering the North Sea. The central part receives water from the south and north at a greatly varying temperature during the course of the year. In summer the surface water coming from the south, from rivers, and from the Baltic, is warm; whilst the water from the north, passing by and over shallow waters, is cold. In winter this condition of things is reversed, as the shallow southern part then grows cold; the same applies to the Baltic and river water, whilst in the north the branch of the Gulf Stream which enters the North Sea is comparatively warm.

"The northern part, as far as the temperature is concerned, entirely depends on the currents of the ocean, the above-mentioned branch of the Gulf Stream, and a deep, cold under-current coming from the north. Thus the distribution of warmth is constantly changing throughout the year. . . . In January the water is warm in the north and in the extreme south, in the former region on account of the Gulf Stream, and in the latter on account of the warm water from southern latitudes. Along the German coast, the water is cold on account of the Elbe and Baltic water. February closely resembles January; and even in March the water on our coast is cold. In April this condition begins to be reversed, and the water on our coast grows warmer; in May and June the temperature of the water is low as far as the Doggerbank, whilst during these months the shallow southern part of the coast waters, which receive much Baltic and Elbe water, are much warmer.

"From July to September the water keeps warm in the southern and south-western parts of the North Sea, a circumstance well known in our North Sea watering places, which are frequented till far into September. In October the water begins to cool off, beginning at the Baltic, and continues to grow cooler during November and December." ('The Physical Condition of the Baltic and the North Sea,' pp. 531–533). There can be no doubt that there is an intimate connection between the temperature of the sea and its animal life; and that the temperature varies in different parts at different times of the year. The herrings appear earlier in the northern part of the North Sea because it is warmed by the Gulf Stream and is deep; they appear later off the coasts of the middle part of the North Sea because the water early in the year is cold, being shallow and easily affected by the atmosphere, and this seems to be the case in the southern part of the same sea extending to the Channel and a part of our southern coasts; but in the south-western the water is warmer on account of the influx of water from southern latitudes.

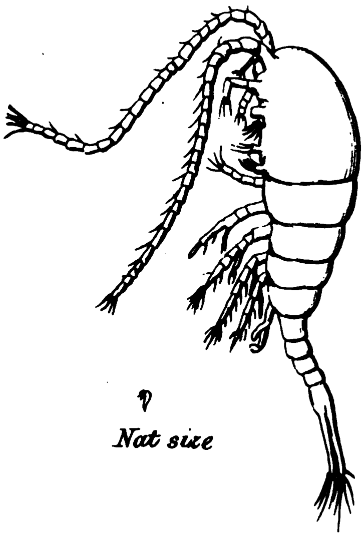
With respect to the herrings of the Baltic and the North Sea, Möbius distinguishes two varieties, differing in some slight structural characters the one from the other; he calls them the coast herring and the sea herring. The coast herring of the Baltic spawns in spring in the shallow coast waters, where the bottom is covered with a rich vegetation. The sea herring spawns in deep water, and its principal habitation is the North Sea. The sea herring of the Baltic spawns at a depth of 4 to 5 mètres. "Sea herrings only make their appearance a short time before the spawning season, as migratory fish, coming in dense shoals, and soon afterwards disappear again. Coast herrings, on the other hand, stay near the coast all the year round, in greater or smaller numbers" (p. 534).

It may be asked, if herrings spawn in the spring in the Baltic, why do they not spawn about the same time in the middle part of the North Sea? The reason may perhaps be, because the shallow water of the Baltic is soon warmed by the sun and atmosphere at that time of the year, while the water of the middle portion of the North Sea is still cold at its surface, being influenced by the large body of water which passes by and over shallow places from the north. A complete and satisfactory explanation of the various phenomena which appear to influence the herrings in their movements remains to be yet given ; but the researches of the German scientists are most valuable and suggestive, and seem to open the way to a full solution of a problem which has puzzled the world of naturalists for many years.

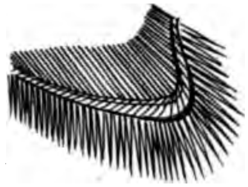
*Food of.*—The food-question is intimately connected with the movements of the herring which have already been treated of above ; it remains to enquire what is the nature of the food. There is no doubt that the principal food of the herring is small crustaceans, which consist of the larvæ of decapods and entomostraca ; the fry and ova of other fishes and even of their own species are also consumed, as well as worms and small molluscs. The abundance of small crustacean food in the stomachs of herrings has been noticed by writers, both old and modern. From the absence of food in the stomach during the spawning season, or from not noticing the crustacean remains in the intestines, some of the old authors thought herrings lived only on water ; "ex puro aquæ elemento vivit, sicut salamandra ex igne ;" an idea which Albertus Magnus declares to be erroneous (see Gesner, 'De Aquat.,' p. 410). The structure of the herring's branchial apparatus is well suited for separating minute crustacean food from the water which it receives into its mouth ; the anterior border of the gills is furnished with a row of slender filaments (gill-rakers) which are covered with small spines. (Plate II., Fig. 3.) Through this grating of spinous points the water containing minute food must pass; the food-particles are collected in this fine grating and accumulate in the gill-cavity, and then swallowed. Enormous quantities of these minute crustacea are devoured by a single herring. Möbius found in the month of February 15,000 small crustaceans in the stomach of one herring, in another 19,000, and in a third one as many as 60,000. Each little creature was about the $\frac{1}{15}$th of an inch in length. The species was the *Temora longicornis*, one of the most abundant of the British *Copepoda* occurring in great profusion in tidal pools amongst seaweeds, as well as in the open sea. (Plate VI.) This is the species I have myself observed most frequently in the herrings whose stomachs and intestines I have examined. By feeding on this kind of food the herrings get very fat and very well flavoured, and their excrements have a reddish colour; according to Möbius, when herrings eat small worms the excrement is yellowish, and of dark colour when they feed on "floating snails or mussels."

As Mr. Sim has paid a good deal of attention to the nature of herring's food, it will be well to quote his remarks somewhat fully.

"The object of my labour," he says, "has been to know really what animals do constitute the herring's food; and before the true state of the case could be reached, the work had to be carried on throughout the whole year as the fish could be obtained; and this has been done for the years 1878, 1879 and 1880. For the first year I kept no note
the number of fish examined, but am safe to say the
ber was fully over that of the two following seasons.
79, 223 fish passed through my hands, and in 1880,
ght at various places along the east coast, from



*Temora Longicornis (Male)*
*Herring Food*



*The Arch of a gill of the Herring*
*(Nat. Size)*

Inverness on to and including the Firth of Forth—the contents of the stomachs of each fish being examined microscopically, and in them were found their own young, their own spawn and scales, and young sprats. Of stalk-eyed crustacea very small individuals of the genus *Galathea*, *Mysis spiritus*, *Thysanoessa borealis*, and *Thysanoessa Aberdonensis*, *Thysanopoda Couchii* and *Acanthocaris Livingstoniana*,* as also several larval forms of *Brachyurus decapoda*, some of them in great abundance. Of sessile-eyed crustacea there were *Hyperia galba*, *Lestrigonus spinidorsalis* and one species of the genus *Æga*. Of entomostraca, *Cythere acuta*, *Cythere minna*, *Temora longicornis*, and another species of *Temora* not identified specifically, and *Evadne Nordmanni*. Young univalve mollusca; *Sagitta bipunctata* (?); also a small fly and small beetle; and an opaque fleshy substance which I think is the skin of a cuttle-fish . . . Of the creatures in the foregoing list, *Hyperia galba*, *Sagitta bipunctata*, the entomostraca *Mysis spiritus*, and young herrings and sprats, form by far the greatest proportion of the herring's food, and these appear to be taken at particular seasons of the year, as, for example, young herrings and sprats I find in greatest abundance from December till May. From May to October, on opening the stomachs, a mass of what looks something like wet vermilion is usually to be found, and this on examination proves to be *Temora longicornis*, with sometimes a few specimens of *Sagitta bipunctata* amongst them. From the beginning of December till February, *Hyperia galba*, along with *Sagitta bipunctata*, form the principal part of the diet. Of course I do not mean that this is an invariable law; it is merely given as what has been observed during the time I have been engaged on the subject. The other creatures mentioned seem to be a sort of chance food taken as it turns up. One thing which has struck me as strange in this subject is that *Amathylla Sabini* and *Atylus Swammerdamii*, two species of sessile-eyed crustacea which literally swarm along our coasts, neither of the two (*sic*) have I ever seen in the herring's stomach, and yet I have found both species adhering to the body of herrings when brought to land. How should this be? The difference in general appearance (apart from the eyes) between *Atylus Swammerdamii* and *Hyperia galba* is not so great as to lead us to think that herrings could perceive a difference, yet the former is passed by, while the latter is devoured in millions. Can taste and smell have anything to do in the matter?" ('Fish and Fisheries,' p. 41–42.)

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* I know nothing of the genera *Acanthocaris* and *Thysanoessa*.

Mr. Sim's investigations as to the nature of herring-food are valuable, because he has examined a very large number of stomachs, and therefore their contents must give a fair idea of the herring's food. I myself have examined a great many stomachs, but not so many as passed under Mr. Sim's hands. The evidence derived from all authorities points to the fact that the small entomostracous crustacea are the chief food. One is at first rather struck by the comparative absence of food in the herring's stomachs derived from the sessile-eyed crustacea, *Amphipoda* and *Isopoda*. If we take the natatorial amphipoda, for instance, and consider how many genera there are that could afford supplies of nutritious food, both from their numbers and swimming-powers, one wonders that in the hundreds of stomachs examined by Mr. Sim, the representatives of only two genera, *Hyperia* and *Æga*, have been found by this gentleman. Many of the amphipoda are strictly toral, being found only or chiefly at tide-marks, and hide stones or amid sea-weed; but there are free water-swimmers among several of the genera. Still most of these natatorial crustacea, though able to swim, do not as a rule frequent the surface of the water, or swim in midwater; they prefer the vicinity of the ground, as is proved by the specimens brought up from deep water by the dredge; they are therefore not so likely to constitute food for herrings as the more numerous surface entomostraca. The genera found to occur in the herring's stomach are *Hyperia*, *Lestrigonus*, and *Æga*, as mentioned by Mr. Sim; but as there is no doubt that *Lestrigonus* is simply the male of *Hyperia*, characterised by extremely long antennæ, the genera are reduced to two. Now both these crustacea are undoubted parasites at some period of their existence. "The numbers of *Hyperiidæ* which are at times cast upon our beach is really extraordinary. As an instance in point, on 23rd Nov. 1879, there were cast up at high-water mark (Aberdeen Bay) millions on millions of *Lestrigonus exulans* and *Hyperia galba* (Plate. I.); a band a yard or two broad and about 400 yards long was formed of them. Although they are often cast up, this was by far the largest number I have seen at one time. They were one wriggling, seething mass, each fighting with its neighbour, and in their death-struggles tearing off each other's limbs, and after an hour's torture became a mass of inanimate matter" (p. 42). It is certainly very curious to note that the abundant and widely distributed *Amathylla Sabini*, which the late Professor Kinahan found in the herring nets at Bray on the Irish coast, and which Mr. Sim tells us he has seen adhering to the body of herrings, does not appear to constitute their food in these northern and western localities where it has been chiefly observed. The absence of *Atylus Swammerdamii* from the herring's stomach is still more strange; for it bears considerable resemblance to *Lestrigonus*

*Kinahani* (male of *Hyperia*), in general form and size, and in the length of the antennæ.

So far, then, as reliance can be placed on negative evidence, the only genera of the sessile-eyed crustacea found in herrings' stomachs are the parasitic *Hyperia* and *Æga* (fish-louse). The *Hyperiidæ* are found within the gill-cavities of *Medusæ*, or "jelly-fishes;" not however, as at one time was thought, only as parasites on *Medusæ*, but as parasites, or "messmates" on these creatures at certain periods of their existence; as voluntary and occasional visitors to the jelly-fishes as mature *Hyperiæ*; as necessary parasites during their infancy. The larval forms of these amphipods, destitute of abdominal feet, are helpless little creatures which cannot swim; they are therefore under the necessity of attaching themselves to some moving body or other, which seems to be, in their case, always some *Medusa*. The adult *Hyperiæ* are found both as parasites and as free oceanic swimmers, among the swiftest of the whole order, perhaps. (Of *H. Latreillii*, Van Beneden remarks: "Il nage avec une rapidité extrême;") so Mr. Sim's opinion that the presence of *Hyperia galba* is more a matter of accident than otherwise, can hardly be accepted as the correct explanation. Fritz Müller traced the development of a larval *Hyperia*, and some interesting remarks on the subject will be found in his admirable little work, 'Facts and Arguments for Darwin' (London, 1869; John Murray). Now he says that *Hyperia* are not uncommon upon ctenophora, especially *Beroë gilva*, Eschsch. Some authors have asserted that herrings consume the smaller *Medusæ* during those periods
e year when these jelly-fish are to be met with. Thus
by—a very good authority on Natural History
says, "They (herrings) subsist on the smaller

cancri, medusæ, and animalcules." ('Arctic Regions,' i. p. 546.) Yarrell says, "they are known to feed upon minute crustacea, small medusæ, and the spawn of fry and fishes." Mr. de Caux, in his book on the 'Herring and the Herring Fishery' (1881), says that "herrings suck or draw from the water for their own nourishment those medusan organisms which, though invisible to the naked eye, swarm around them." On this Mr. Sim remarks, "It would have been satisfactory had this writer stated whether he had seen medusæ in the herring's stomach. I doubt it." Certainly it would be a very difficult if not impossible task to attempt to discover evidences of such excessively fragile and perishable creatures as the small medusæ, such as *Beroë* and *Cydippe*, in the stomach of a herring. Such delicate globules of transparent evanescence could not reveal themselves; on this account their non-detection in the herring's stomach is of no weight against the opinion that such creatures do form occasional food. Does not the huge Greenland whale consume immense quantities of the little soft-bodied mollusc (*Clio borealis*), as well as jelly-fishes of various kinds? Can there be nutriment in the watery unsubstantiality of the jelly-fish? Yes, because the jelly-fishes feed largely on *Diatomaceæ*, the well-known forms of algal growth which are to be found almost everywhere and always. The mighty whale then derives part of the food-material which helps to build up his colossal frame from microscopic organisms, thousands of which could be contained on a shilling-piece! So that the whale does not get direct food from the swallowed jelly-fish, but from the diatomaceæ which the jelly-fish contain. This is a phenomenon which Nature often permits us to witness; some creatures swallow others, the whole of whose unsubstantial organisation in itself contains hardly a particle of nutritious matter, and are nourished by the food that the swallowed ones had themselves swallowed.

Let us return to the *Hyperiæ*, and see whether the abundant supply of this crustacean food in the herring's stomach may not have some probable explanation, and throw light upon the reason for herrings consuming watery medusæ. The *Hyperia* in its infancy is, of necessity, parasitic upon small medusæ; in its adult state *Hyperia* is sometimes a parasite and sometimes a free swimmer. The nutritive material contained in a *Beroë's* or *Cydippe's* body in the shape of *diatomaceæ* is a good reason for the herring's consuming it. The herring would therefore acquire a habit of eating medusæ, and as *Hyperia galba* would often be, from the fact of its parasitism, associated with medusæ, the herrings would constantly meet with the *Hyperiæ;* whereas the other natatorial amphipoda, from their more littoral and less surface-swimming habits, would be less frequently met with in any numbers. Those who have been in the habit of using the surface-net know how abundantly the small jelly-fishes, such as *Beroë* and *Cydippe*, occur at the top of the water when the weather is calm and sunny, and I have myself captured numbers in company with entomostraca, crab and other decapod-larvæ when trawling 60 miles from land in the North Sea, last July. Of course I do not consider my explanation as anything more than a probable one. *Sagitta*, thus associated, I obtained in a surface-net at the same time, whenever the net was examined, and it will be remembered that Mr. Sim found *Sagitta bipunctata* frequently in the machs of herrings. The other genus *Æga*, which Sim found represented in the herring's stomach, is one *Isopoda* which are more decided crawlers and are unable to swim. In some state or other the *Ægidæ* are parasitic upon fish, and probably may get into the herring's stomach with some fish which the latter had swallowed.

The species of stalk-eyed crustacea mentioned by Mr. Sim require no special notice, being such as herrings would at one time or another be likely to meet with, especially in their young stage when, after the completion of the Zoëa stage, they would be found abundantly as surface-swimmers.

The herring, it is probable, has no particular predilection for one kind of crustaceous animal over another; the requisite conditions for food would depend on their small size and abundance in the waters and depth of waters where the herrings would be at any time. Surface crustacea, whether larval forms, be they *nauplioid*, *zoëoid* or *Mysis* form, or adult specimens of various kinds, would constitute the greater proportion of crustacean diet, because they would fulfil the necessary conditions just mentioned.

I have examined a great number of the young of the herring, and find the food to consist chiefly of minute copepoda, mixed with fine particles of mud, and some *diatomaceæ*. Dr. H. A. Meyer has examined young herrings caught from the Bay of Kiel; he records as having observed in their stomachs, "the larvæ of *Rissoa*, *Ulva*, (?) *Tellina*, *Cardium*, &c., and occasionally the larvæ of Nauplius, whilst when they grow somewhat larger they will eagerly devour full-grown Copepods." Ljungman says that the food of the herring belongs exclusively to the animal kingdom; I think that this statement requires a little modification, their food is almost entirely of an animal nature, but diatomaceæ are occasionally to be found in their stomachs, which I think have been swallowed with the small creatures which feed to a considerable extent on these minute vegetable organisms. The pilchard in October feeds principally on diatomaceæ, which these fishes take directly from the water or ground; in young herrings' stomachs I have frequently found diatomaceæ, but not in great abundance as in those of pilchards.

A small stalk-eyed crustacean, the *Thysanopoda Couchii*, one of the *Mysidæ* or opossum shrimps, so called from the fact that the female hatches her eggs in a kind of pouch formed by the last two feet, appears to enter largely into the herring's diet. Large patches of sea-water are sometimes coloured quite red from its abundance in our own waters; but on the coasts of Norway, another species, the *Thysanopoda inermis*, is found in such prodigious numbers as to supply food even to the whale. According to Collett, a Norwegian naturalist, the great blue whale visits the Norway waters for the purpose of feeding on this crustacean; at the end of May it enters the larger fiords and feasts on this favourite food, filling its stomach to the amount of barrels-full. The "roé-aat," *Astacus harengum* of the old writers, appears to refer to the above-named crustacean, but of this I am not at all certain. However, in Norway herrings which had gorged themselves with such food are called *aated*, and during the warm season are supposed to be less valuable as food. Young sand-eels are said to be a favourite food, and doubtless when herrings meet with them they would devour them with avidity.

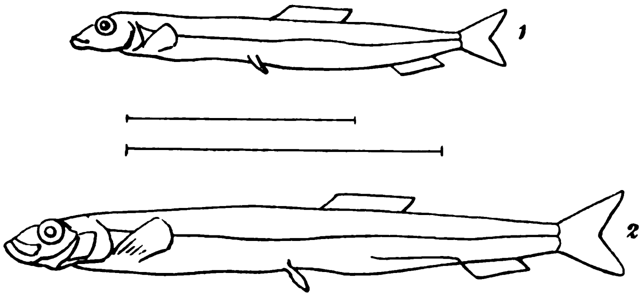
*Spawning.*—As this has been already mentioned under the heading of General Habits, it only remains to notice the mode of deposition of the spawn and the development
growth of the young fishes. During the spawning pro-
milters swim by the side of the females in immense
; the smaller schools gather into larger ones, and

finally, as Möbius tells us, "assume such enormous dimensions as to deserve the name of "herring mountains." When such an enormous mass of herrings approaches the coast, we are also informed, it gives a peculiar colour to the water, and when near the surface creates a considerable commotion in the water. According to Gisler and the Bohuslän fishermen, the herrings during the spawning season "push against each other with such violence that many of their scales come off and float about near the surface." The shoals swim at different depths under the water, according to external causes. The impregnated eggs after exclusion sink down in the water, and when they touch the bottom, weed, or submerged body they adhere by a sticky substance which covers them. Möbius figures a piece of water-plant, *Potamogeton pectinalis*, with clusters of eggs, either singly or in small groups attached, taken from the Schlei, a river near Kiel. The ova of the cod and the mackerel are furnished at their upper pole with a drop of oil which, diminishing their specific gravity, enables them to float on the surface; the ova of the herring are not thus buoyed up, and consequently they sink to the bottom. These egg-clusters vary considerably in size. A writer, signing himself "Expectans," in 'Land and Water,' Nov. 3rd, 1866, says "it has been known that the spawn which they (herrings) deposit, in some favoured rocky bottom, extended in immense layers six feet thick!" According to the observations of Möbius the sexual organs of herrings measuring less than about 8½ inches in the Bay of Kiel are but little developed, and in specimens measuring from 8½ inches to 11½ inches these organs grow from October to the spawning season in spring. The spawners generally leave the Bay of Kiel in April and enter the shallow brackish waters of the Schlei, their places in the Bay being occupied by smaller herrings measuring less than 8¼ inches in length. There seems to be some slight difference as to the size at which the herring becomes sexually mature. "In the Cattegat along the Swedish coast the smallest fully-matured herring measures 200 to 210 millimeters in length. In the North Sea on the Coast of Scotland they measure 215, and on the west coast of Norway 225 millimeters." In other words, the smallest sexually mature herring may be one of 8 inches on the Swedish coast, while on the west coast of Norway maturity is not reached till the fish is 9 inches in length. Prof. Huxley's opinion that a herring may be "full" when only 7 inches in length appears therefore to be not generally correct. Möbius, in his examination of the Schleswig-Holstein race of coast herring, distinguishes four different stages of age and size which he calls :—

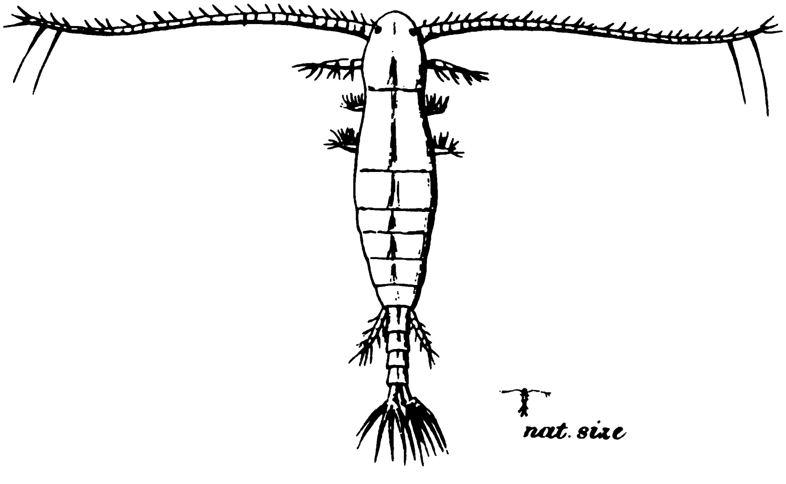
(1) The larval form, (2) the herring form, (3) the middle form, and (4) the sexually mature form.

As to (1), the larval form has hardly yet assumed the true herring form; after the absorption of the umbilical sac, the little creature is "more slender than the juvenile herring, and almost as thin as a ribbon; its dorsal fin is proportionately long and is placed far back." A larva measuring 33 millimeters (about 1⅓ inch) in length is only 2 millimeters (1 line) high, while the height of a herring which has already assumed its juvenile form when measuring 40 millimeters (1⅓ inch) is 6 to 7 millimeters (3 to 3¼ lines) high. The larvæ are transparent. The juvenile form has transparent scales glittering like silver; so that the larval form of the herrings denotes its stage of growth from its birth till it has reached the length of about 1⅓ inch. (Plate VII.)

(2) The young form of the herring is from 40 to 50 millimeters (1⅔ in. to 4⅘ in.) in length. It appears in the



1. Outline of a spring herring larva taken from the Schlei mag$^{d}$ twice. 2. Ditto of an autumn herring larva taken from the Bay of Eckernforde, magnified twice. The lines between them shew the nat. size. (United States Commission &c. p. 541.)



Cetochilus Septentrionalis (magnified)
Herring food.

Bay of Kiel in autumn and winter, whilst in the Schlei it is found all the year round. It may be observed here that the preference of the young herring for the shallow brackish water of the Schlei probably is because of more abundant food, or food obtainable with less expense of muscular force than would be necessary in the Bay waters, and perhaps also because they would meet with fewer fish-enemies.

(3) The middle form measures 120 to 140 millimeters (4⅘ inch to 5⅘ inch) in length. At this age the herrings are generally very fat. The sexual organs are as yet undeveloped. Herrings of this shape and size are frequently caught in the Bays of Kiel and Eckernförde in March and April, and often in February. They compose more than half the number of all the herrings caught in these bays.

(4) The sexually mature herring measures 210 to 290 millimeters in length (8⅕ inch to 11⅗ inch); they are found all through the winter in the Bays of Kiel and Eckernförde. Towards the end of March they disappear and go to the Schlei. This would be for the purpose of spawning.

With respect to the age of the herring at which it first attains its full size, Möbius thinks it probable that this does not take place till the fourth year, but he adds that the observations made hitherto have not led to any absolute certain result. "As soon as the herring has entered its juvenile age the number of rays in all its fins (except the anal fins) does not change any more. At that period the pectoral fin has 17 rays, the ventral fin 9, and dorsal 19." There is also no change in the positions of the dorsal and anal fins and of the anus after that age, though there are slight changes in the height and breadth of the body in relation to its length.

The growth of a fish kept in an aquarium is not always a test or standard whereby we can estimate its growth in its native waters; some fish will thrive and grow, and attain a sexually perfect condition in confinement, others will not.

Dr. H. A. Meyer of Berlin, whose name is well known in all scientific and experimental questions concerning fish, has been more successful than his predecessors in the preservation of the herring in an aquarium. The development of the fish is intimately connected with the condition of the water, suitable food, &c. and Dr. Meyer ('Biologische Beobachtungen bei künstlicher Aufzucht des Herings der westlichen Ostsee'—'Biological Observations on the Artificial Rearing of Herrings in the Western Baltic,' Berlin, 1878) has recorded some valuable information. He succeeded in keeping young fry alive for five months. When but a few days old the desire for food manifested itself, and the little creatures were seen to take in microscopic forms of life, such as infusoria, that appeared in the water; when a month old, they devoured small crustacea. In pure sea-water growth was rapid, and by the end of the third month they attained to a length of about 1⅗ of an inch; in an aquarium the fry did not do so well, and measured only an inch, or an inch and a half in length; but under the more favourable conditions of more abundant food and free sea-water these grew rapidly, and at the end of the fifth month were as large as those which from the first had been placed in more natural conditions. Dr. Meyer did not succeed in keeping the herrings alive beyond five months, at which time about 2¼ or 2⅓ inches in length. Probably in their free state they would have attained a larger size. The growth of fish depends almost entirely upon an abundant supply of nourishing food, and according as these supplies are abundant, or scanty, so will be the size of the ierrings at any given period; so that fish of the same age v exhibit marked differences in point of size. From observations on the rearing of trout, I have known instances of two year-old-fish not attaining to a length of more than 6 or 7 inches in a small confined stew in which there was scanty food for the numbers placed in it, whereas under favourable circumstances, a two-year trout may be a well-conditioned fish of nearly a pound in weight. Age therefore is not by itself any certain test of size in all cases, and the size and the age at which a herring first matures its sexual organs depend upon the food which it has been able to consume and assimilate; and as food-supply is in itself variable, so are the maturing times variable, and some herrings will attain to reproductive capability at an earlier period of life than others. The question, therefore, how old must a herring be before it arrives at sexual maturity? can hardly be rightly answered by fixing the age and size at some definite time of its life, even if that stated time be in some cases correct. Some writers, as Professor Huxley, think that a herring may reach its spawning condition in one year, others say it requires one year and a half, and others say that nearly two years are necessary. It is known that some fishes grow with remarkable rapidity, attain a definite full grown standard, beyond which growth no further goes, in the course of from one to three years. In this sense the term of "full grown" is applied to fishes similarly as it is applied to warm-blooded vertebrates, and herrings having a definite standard of growth will come under that category, and as fishes which grow rapidly to a definite size are short-lived, they must early mature their sexual organs for the all-important function of multiplying their kind. Extended and patient investigations on this subject are still required before we can positively affirm that, even under the most favourable circumstances of temperature and food-supply, herrings, hatched we will say in October, can or cannot be themselves spawners in the October of the following year. Again, we must remember that herrings will grow faster at one period of the year than at another. A larva hatched in March will at the end of four months attain a greater length than one hatched in October will attain at the end of a similar period of four months. What is the reason of this? the temperature is warmer during the four months of the spring-herring's life than it is during those of the autumn fry, and this warmth of temperature acts *directly* on the rapid growth of the herring in the same way as it does on the ova which take a shorter time to reach the point of birth of the embryo when the water is more or less warm, than when it is cold; in the same way that warmth promotes the rapid growth of thousands of other living organisms. Warmth acts also *indirectly* by supplying food in abundant profusion to the small herrings whose happy environment is among these swarms of microscopic food-creatures. With regard to the eggs of the herring, Möbius has proved that they can stand a great degree of saltness. In the North Sea they develop in water whose percentage of saltness is 3·5, on the eastern coast of Rügen in water containing 0·8 per cent. of salt, and on the coasts of Prussia and Scotland in water having an even percentage of saltness." The same with regard to temperature, great differences of which herring eggs are capable of standing. "Their development is not interrupted when they are cooled off by a temperature approaching zero, nor by a temperature rising as high as 15° C. In cold water their development is slower than in warm water. With a temperature of 3·5° the young Baltic herring leaves the egg after 40 days, at 7° to 8° in 15 days, 10° to 11° in 11 days, and with a still higher temperature in 6 to 8 days." Herrings in some localities reach a greater size than they do in others. Eleven to thirteen inches may perhaps be taken to be about the length of a good full-sized fish, but the famous Loch Fyne herrings often attain to the length of 17 inches; the same is the case in Iceland and Labrador. What is the probable reason for this large size? Here, again, one would say that it is owing to a more abundant supply of the most suitable food obtainable, chiefly during the fattening season of the "mattie" state at small expense of muscular force; for if growth, as Mr. Herbert Spencer well shows, is "substantially equivalent to the absorbed nutriment minus the nutriment used up in action," and if during the life of the herring there is an excess of assimilation of nutriment over its expenditure in greater proportions in some localities than in others, then the growth of the herring in those localities will be more rapid and attain greater dimension than that of herrings living in less favoured localities. Possibly the physical formation of Loch Fyne, with its numerous indented coasts and narrow channels, is well suited to the herring, because it would obtain abundant supply of crustacean food within limits which are very narrow compared with the wide expanse of the North Sea, and would require less continued muscular expenditure to obtain such food. With regard to the large size of the Iceland and Labrador herrings, it may probably, I think, be in a great measure accounted for by the extraordinary abundance of entomostracan food which is to be found in the Arctic Seas. Not only are the individuals excessively numerous, they also attain to a great size. Arctic specimens of several *Copepoda*, pre-eminently the food of the herring, attain to a greater size than the same species which occur on our coasts. Dr. Brady tells us by way of example that *Calanus Finmarchicus* and *Metridia armata* are in the Arctic seas "many times the bulk of those taken in our own latitudes." This also holds good in respect of the higher crustacea, Amphipods, &c., as Mr. Norman assures us. Now the *Calanus Finmarchicus* of Boeck is the well-known *Cetochilus septentrionalis* of Goodsir and Baird; it is, as the word *cetochilus* denotes, "the whale food" of the Arctic Ocean and the South Atlantic. (Plate VII.) Mr. Watt says it is the "cow-water" of the Cornish fishery, and we know that it is consumed by herrings as well as by whales in great numbers. The great abundance and large size of this species alone off the coasts of Iceland would probably be sufficient to nourish whole shoals of herrings during a part of the year. How seldom do we recognise the enormous value to ourselves of such minute creatures as this little red semi-transparent copepod about 2 lines in length![*]

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[*] "In the Firth of Forth, Mr. Goodsir informs us that during the summer months great masses of animal matter abound on the surface of the sea, and that this had long been noticed by the fishermen on the coast, and was called by them *maidre*. Upon examining this matter, in the neighbourhood of the Isle of May, he found it to consist of Cirrhopodes, Crustaceans and Acalephæ; but that of all these the entomostraceous crustaceans abounded in the greatest quantity, or rather masses, he observes, "for it gives a faint idea to speak of numbers . . . On looking into the water," he continues, "it was found to be quite obscured by the moving mass of entomostraca, which rendered it impossible to see anything even a few inches below the surface. But if a clear spot is obtained, so as to allow the observer to get a view of the bottom, immense shoals of cod-fish are seen swimming lazily about and devouring their minute prey in great quantities. . . . On one of his visits to the Isle of May he observed that at a considerable distance from the land the sea had assumed a slightly red colour, and that this became deeper and deeper the nearer he approached the island. The water, too, he noticed, presented a very curious appearance on the surface, as if a quantity of fine sand were constantly falling upon it. At first he thought that this might proceed from light rain, but upon more attentive examination he found both the red hue of the water and the motion on its surface proceeded

*Modes of capture.*—By drift-nets and by the seine. As these are the two modes of capturing not only herrings but mackerel and pilchards, it may be well here to give some account of this very important kind of fishing; and as the subjects have been so well treated of by Mr. E. W. H. Holdsworth, who acted as secretary to the Royal Sea Fisheries Commission, 1863–1865, and who is one of the most competent authorities on matters relating to the sea fisheries, I prefer to use Mr. Holdsworth's own admirably expressed language. He writes:—

"The term 'drift-nets' is derived from the manner in which the nets are worked. They are neither fixed, towed nor hauled within any precise limits of water; but are cast out or 'shot,' the technical expression for throwing out or putting a net into the water, at any distance from the land where there are signs of fish, and are allowed to drift in any direction that the tide may happen to take them, until it is thought desirable to haul them in. When at work, they are extended in a long line, it may be one or two miles in length, their upper edge being supported at or near the surface by means of floats, the nets hanging perpendicularly in the water, and forming, as it were, a perforated wall or barrier many hundred yards long and seventy yards deep. The shoals of fish, in their endeavours to pass through this barrier, force their heads into the meshes, the size of the mesh used depending on whether herrings, mackerel or pilchards are expected to be caught, and being such as to allow the head and gill-covers to enter, but not to permit the thicker body of the fish to go through.

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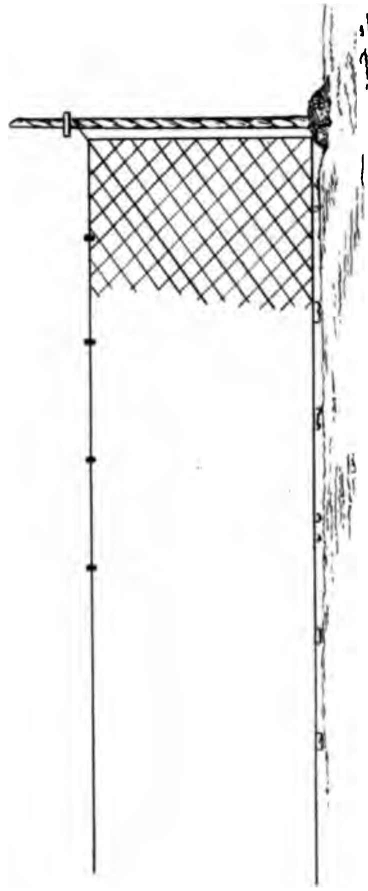
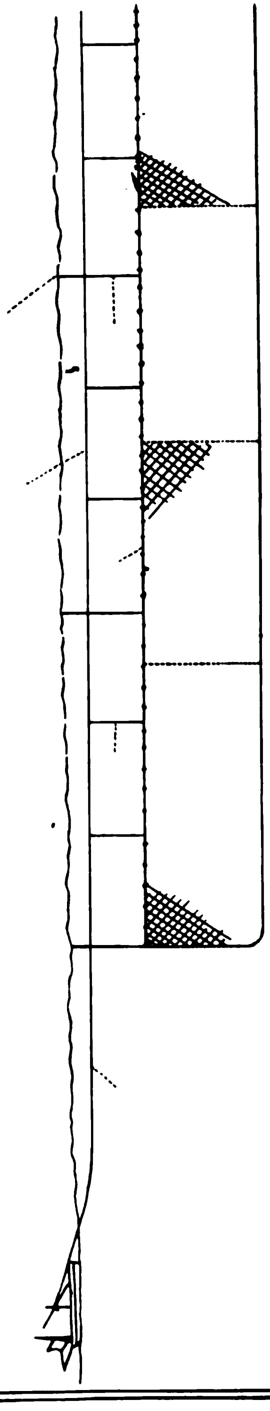
from an immense number of small entomostracea. Some of these he collected and found them to be a species of Cetochilus." ('Nat. Hist. Brit. Entomostraca,' Baird, pp. 234, 235.)

When the fish has found its way through the net beyond the gill-covers, it may generally be considered as effectually meshed ; there is indeed little chance of its escape, for the mesh is only large enough for a fish of average size to push its way so far, when the gill covers are laid close to the body ; but it is necessary for them to open again that the fish may breathe, that is that the water which enters the mouth may, with the air it contains, pass over the gills, and after purifying the blood within them, just as the air we take into our lungs purifies the blood they contain, escape through the gill-opening on each side of the head. As this is taking place, and the fish is at the same time hampered by the net, the mesh slips forward and catches in the gill-opening, from which it cannot easily be cleared without more or less injury to the fish. In drift-net fishing, then, the nets act as barriers to intercept the moving shoals, and the fish become meshed in their attempt to pass through. It is found that certain conditions are favourable for drift-net fishing. It will be readily understood that the more indistinct the net is in the water, the more likely the fish are to swim against it and to become meshed. The night is therefore, with extremely rare exceptions, the time chosen for drift-fishing ; and it is noticed that just after sun-set and just before sun-rise, when the change is taking place from light to darkness, or the reverse, herrings especially are most likely to 'strike' the net as it is called. This is a point in connection with the habits of the herring which is little understood. A ripple on the surface of the water is also a favourable condition ; and this is easily explained ; for if the surface of the sea be at all broken, such light as falls upon it is reflected by every little wave, and therefore does not penetrate to the nets so as to make them visible. . . . For a description of drift-nets and the



SET NET.



DRIFT NET.

mode of working them on a large scale I cannot do better than give some account of the method by which the Yarmouth herring fishery has long been carried on. Drift-fishing, 'drifting' or 'driving,' as it is variously called, although the last term is the one in general use among the fishermen, is there worked with fine sea-going decked boats, larger in every way than those similarly used on other parts of our coasts; and the fishermen can consequently venture farther to sea, and run the chance of worse weather, than most of the smaller boats are capable of doing with a due regard to safety. (Plate VIII.)

"The nets used for drift-fishing are made either of cotton or hemp, 'twine,' as the latter is called, some fishermen preferring one material, some the other, and it is not unusual for the two kinds to be placed alternately in the same train of nets. Cotton nets are finer in the line and more flexible than those made of hemp, and they are generally believed to be more effective in meshing the fish. Machinery of a very beautiful and ingenious character is employed in making these nets, and large supplies have been for some years past turned out from the factories at Bridport, Musselburgh and many other towns. Cotton nets are now very largely used, and there is every reason to think that they will be universally employed for all kinds of drift-fishing.* When new, they are first saturated with linseed oil, then squeezed through a machine, afterwards dried, which takes some days, and finally they are put into a vat and hot bark liquor is poured upon them; in this they remain for two or three days. The bark liquor is a preparation in which catechu is an important ingredient, it having practically superseded the oak bark formerly used for tanning nets. In some cases the nets are dressed with coal-tar instead of being barked. The herring nets come from the factory in 'pieces,' 60 yards long, and 9 or 10 yards deep, the depth of the net containing 200 meshes; and it is the custom of the fishermen, when speaking of the size of a net, to say it is so many yards long and so many meshes deep, as the case may be. Each piece is divided into two nets 30 yards long. When a net is prepared for use, it is 'mounted,' or fastened lengthwise along one edge to a small line only 18 or 20 yards long, that length of line being appropriated to the 30 yards of net, so that the 'lint,' or netting, is set slack, and gives way a little when the fish strike it; and from its flexibility the net holds the fish better than would be the case if it were fully stretched. The ends of the net are called the 'heads,' the roped edge of the length the 'back,' as that is uppermost when the net is in the water, and the lower edge of the net the 'foot' or 'sole.' The heads are roped as well as the back, but the foot is usually left free, so as to be less likely to hitch in anything at the bottom, when the nets chance to be used in rather shoal water or near the ground. The back of the net is further fastened at intervals of a few inches by a very short line called 'nossles' to the cork-rope, a small double rope enclosing at various distances pieces of cork as floats, to keep that part of the net uppermost. The number of such nets used by each vessel depends very much on her size, and ranges from eighty to one hundred and thirty. They are fastened together end to end, and thus united form what is called a 'train, fleet or drift of nets,' frequently extending to a length of more than a mile and a quarter. The mesh in a herring net is about an inch and a quarter square, equivalent to thirty or thirty-two meshes to the yard when the net is new; but after long use and frequent barking or tarring, it becomes contracted to an inch or even less. . . . .

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* The cotton net is now, 1883, generally employed in herring fishing.

"The time universally chosen for putting out, or 'shooting' the nets as it is called, is just before sunset, and the vessel being in what the master has reason to think is a likely place for fish—a point, however, about which there is some speculation—she is put before the wind, and as she sails slowly away the net is shot over her quarter, that is over the side near the stern. Whilst this is going on, the men are distributed at regular stations, some hauling up the net from below, others throwing it over and taking care that it falls in the right position; others, again, looking after the warp and seeing that the 'seizings' are made fast to it in their proper places. When all the net is overboard and fifteen or twenty fathoms of extra warp, termed the 'swing rope,' are paid out, the warp is carried from the stern to the bow of the vessel; she is then brought round head to wind, the ordinary sails are taken in, the mast is lowered till it rests in the crutch of the mitch-boards; a small mizen sail called the 'drift-mizen' is set to keep her head to wind, and the regulation lights are put up to show that the vessel is fishing. A certain number of men then remain on the deck as the watch, and the vessel and nets drift with the tide.

"It is important that a strain should be kept on the nets, so as to extend them; it will therefore be readily understood why the nets are shot in the direction in which the wind, much or little, is blowing; for the vessel being to leeward of the nets when they are in the water, and offering of course more resistance to the wind than they do, drifts more rapidly, and consequently pulls upon the nets and keeps them comparatively straight. . . . Whilst the nets are in the water, the warp is occasionally hauled in till the first net is reached; this is called the 'look on' net, and by examining it some idea may generally be formed of whether many herrings are about, or the dog-fish are numerous. The latter are at times very mischievous, and do a great deal of damage to both the fish and the nets if they are left long in the water.

"I now come to hauling in the nets; this operation is performed in the same systematic manner as I spoke of just now in connection with shooting the nets, the men being told off to their regular stations and each having his appointed duty. I need only mention that the 'capstan men' are now important persons, for the capstan is the means by which the warp and nets are got on board. As soon as the fish are all shaken out of the nets, they are sprinkled with salt and then stowed away in their proper compartments in the hold of the vessel. When the night's fishing is over, the mast is got upright again, the sails are set, and the vessel either returns to port, or, if the catch of fish has been small, shifts to a fresh berth for the next night's work." (British Industries, 'Sea and Salmon Fsheries,' pp. 49–61. See also Mr. Holdsworth's larger work, 'Deep Sea Fishing and Fishing Boats,' 1874; also the article on "Fisheries," in the last edition of the 'Encyclopædia Britannica.')

On sean fishing, the method of enclosing a number of fishes by means of a net drawn circularly around them, Mr. Holdsworth writes:—

"The seans used in this country are of three kinds, namely, the sean proper—sometimes called the 'stop sean,' the tuck sean, and the ground or foot sean. One special character, however, is common to them all—they surround or enclose the fish, and the differences between them relate almost entirely to the manner in which the nets are worked. A sean consists of a long train of netting, which may vary in length and depth, according to what it is required for; but it is always deeper in the middle or 'bunt' than at the 'sleeves' or 'wings,' as the ends are called. The object of making the middle of the net deeper than the ends is to give the enclosed fish less opportunity of escaping underneath when the net is being hauled in, as that is the part of the net where the fish congregate under such circumstances; and when the net is being hauled on shore, its gradual deepening from the ends towards the middle or bunt enables the whole of the foot or lower edge, in most cases, to touch the shelving bottom at the same time, and so to effectually prevent the escape of the enclosed fish in that direction. The net is thrown out or shot in a semicircle if it is to be hauled on shore, or often in a complete circle if it is intended to be worked entirely from the boats. In either case the ends are sooner or later brought together, and the fish are completely surrounded. The back or upper edge is well supported at the surface by corks, which is very necessary, as the fish mostly caught by the sean are those which commonly keep near the top of the water; and the food is weighted with leads to keep it down, so that the whole wall of netting may hang perpendicularly from the corks. There is no part of our coast where seaning can be seen more effectively worked, or on a larger scale, than in Cornwall. St. Ives has long been famed for its pilchard fishery; and fluctuating, as it has been, the proceeds are so valuable, in even a moderately good season, that for many years it has been thought worth while to keep between 200 and 300 large seans ready for work, and to take their turn in the limited space available for their proper employment. Two or sometimes three nets are here used for enclosing a shoal of fish or part of it if it is a large one. The first or principal net, spoken of as the sean, is about 200 fathoms long and 10 fathoms at its deepest part, and another net of the same kind called the 'stop-sean' is fastened to it. These nets are shot at the same time, the boats starting with them from the point where they are joined together; and in a position rather on the outside of the shoal of fish, if they are at a convenient distance from the shore; the boat with the sean throwing out the net in a direction parallel with the shore, while the stop-sean is shot as the boat is rowed towards the beach. The two boats ultimately turn towards each other, thus completely surrounding the fish. The nets are then fastened together at the point of meeting, and the circle gradually contracted by hauling up the stop-sean until the whole of the fish are enclosed by the large sean alone. If there be a probability of enclosing a very large number of fish, a second stop-sean is fastened to the first before the circle of nets is completed; but this is only required on rare occasions, and in any case the fish are ultimately brought within the compass of the single large sean. When this has been accomplished, the whole circle of netting with the enclosed fish is slowly hauled towards the shore, into some quiet place out of the tide, if possible, till the foot of the net touches the bottom, and there it is securely moored. This is necessary, because the hauls of fish are sometimes so large that several days may elapse before the net can be emptied. Now comes the operation of what is called 'tucking' the fish. For this purpose another net, called the 'tuck-sean,' is employed. It is only seventy or eighty fathoms long, but very deep at the bunt or middle; it is shot inside the circle formed by the large sean, and as it is hauled in, the foot of the bunt is raised so as to get the net under the fish and bring them to the surface, whence they are taken out in large baskets and put into the boats to be carried on shore.

"I have now spoken of the sean proper and the tuck-sean, and I have only to describe the ground- or foot-sean, in some places called the scringe-net. This sean is much more widely known than the others, for it can be very easily worked, and one of even very small size may be the means of catching a great variety of fish. The peculiarity in its working consists simply in the net being always hauled on shore, and that being the case, there is no necessity for the meshes at the wings being as small as is desirable at the bunt or middle of the net, where the fish sooner or later collect, and the greatest pressure is felt. Each wing has a pole to which the ends of the upper and lower edges of the net are fastened, and to this pole a long drag-rope is attached for the purpose of hauling in the net. When the sean is to be shot, the end of one of the drag-ropes is left on shore in charge of some of the fishermen, and the whole of the net with the rope at the other end is put into the sean-boat, which is then rowed out from the shore, and after shooting the net in a semicircle, returns with the second rope to the beach. The two ropes are then slowly hauled in, the two parties of fishermen gradually approaching each other as the net comes to land, until at last they meet, and the bunt of the net, in which all the fish are collected, is then drawn on shore. The bunt is in all cases made of much smaller meshes than the other parts, as the object is to enclose the fish, and not to mesh them, as in the drift-nets" ('Sea Fisheries,' pp. 88–93).

It ought to be mentioned that sean-fishing for herrings in Scotland is usually designated by the term "trawling;" it is necessary, therefore, to use the expression of "sean-trawling" if the word "trawling" is retained, otherwise there would be confusion between the herring-trawling in Scotland and trawling or beam-trawling, as expressing in other parts of the United Kingdom an actually different mode of capturing fishes.

Herrings in large quantities and of all sizes are occasionally taken in "cruives" or "wicker-baskets of a particular form, fixed in the tideway of some of our rivers and coasts" (Mitchell); also by hooks baited or unbaited, and by artificial flies. Mr. Holdsworth mentions a peculiar method of line fishing for herrings, as practised chiefly on the eastern side of the Scotch coasts, called dandy-line fishing; the apparatus consists of a line having a leaden plummet at the bottom about 4 lbs. in weight, and above it, at intervals of eight inches, a series of pieces of whalebone having at each end a short line with a bright tinned hook; these are fastened at right angles to the line, the whole is lowered into the water, and gently moved up and down, the distance to which it is sunk depending on where the herrings are likely to be most numerous at the time. No bait of any kind is used, the bright hooks being sufficiently attractive. Doubtless the glittering moving hooks are mistaken by the herrings for the small fry of fish. Probably, as Mr. Holdsworth suggests, the term "dandy-line" is merely one which is more than usually smart and prettily mounted.

"It is difficult by merely looking at figures," Mr. Holdsworth truly remarks, "to fully realise the enormous number of herrings taken every year on the coast of Scotland alone; but if the low average of 750 fish be allowed for each barrel, we find that no less than 500 millions of herrings were cured in 1872, besides an unknown but undoubtedly very large number disposed of fresh. And when it is remembered that there is no good reason for believing that man takes no more than a very small percentage of the herrings around our coasts, any attempt to estimate the number and extent of the shoals only leads one into a state of hopeless bewilderment."

Owing to the close and compact masses which shoal-herrings form, the capture is attended with great uncertainty. Some boats may be eminently successful and catch enormous numbers; others, again, not any great distance removed, may meet with little or no success. The same uncertainty attaches to pilchard fishing; one boat may fall in with a shoal, and a number of others fail to do so.

In some parts of the coast herrings are caught by stake-nets, i.e. nets fixed by poles in the sand at low water, the net offering a barrier to any herrings or other fish that may happen to be swimming in its direction. Many series of these stake-nets may be seen on the Welsh coast between Rhyl and Conway in the months of October and November. What fish, however, that are caught are rather stray herrings from the great shoals; and of course such a mode of fishing is very uncertain in results.

*Quality of flesh.*—Of delicate and delicious flavour and easy of digestion, and because it is caught in such enormous numbers, and is, moreover, a cheap fish, compared with most other fish that have high edible merits, the herring, as affording excellent food to man, is unsurpassed by any fish that swims in British waters. They are generally in season for the greater part of the year at some portion or other of our coasts, depending on the different times at which they spawn. After spawning they are for some time thin, soft, watery, and insipid. This condition is expressed by the term "shotten," i.e. a herring that has "shot" or ejected its spawn. In the months of March, April, and part of May, the herrings on the greater part of our coasts are poor, from the effects of spawning. Numbers are caught at this time, which is that of the spring fishery. They are sold at a cheap rate, sometimes not fetching more than a few pence per hundred, and sold for manure, or for baits for line fish as cod and ling. In this latter capacity even the shotten herring is of value, and it would be a great mistake to prohibit the catching of these spring fish ; the fish products of the sea are on so vast a scale that man can neither add to nor take away therefrom so as to reduce or multiply the numbers to any appreciable extent.

*Commercial value.*—The herring is, without exception, the most important of all fishes to the people of this country, but especially to the poorer classes. Being of a perishable nature, the herring does not keep long in a fresh state ; hence the necessity of curing it ; and it is in this form that its chief value consists. The fishermen on the east coast, as at Lowestoft and Yarmouth, recognise three distinct fisheries, the spring, the mid-summer and the autumn or winter fisheries. The spring-fishery was not much attended to till about 1850 or 1852, but it soon grew into importance and has been continued with varying success in subsequent years (Holdsworth). It usually begins about the middle of March, but the fish, as already mentioned, are poor and of little value as food at that time. The summer fishing follows the spring without any considerable interval ; at this time the fish are in better condition, but as yet as a rule without or with very immature roes. The principal herring fishing begins early in September, and continues till late in the winter. It is impossible to form any true idea of the enormous quantities of herrings captured and consumed during the year. Mr. Mayhew in 1861 gives the number of herrings disposed of in the metropolis by the street-sellers alone as 857,000,000, having a weight of 210,000,000 lbs., which is more than 30 times the number of plaice which come next in point of numbers.

Scotland has long been famous for the abundance and excellency of its herrings. The Commissioners of the Scotch Fishery Board have for a number of years published reports of the total number of herrings cured, branded and exported year by year, from the 1st of June, 1809, to the present time. The abstract of the total number cured for the last 10 years, ending December, 1881, gives the following annual return:—

| | | | | |
|---|---|---|---|---|
| Year ending | 31 Dec., | 1871 | 825,475¾ | barrels. |
| " | " | 1872 | 773,859½ | " |
| " | " | 1873 | 939,233½ | " |
| " | " | 1874 | 1,000,561 | " |
| " | " | 1875 | 942,980 | " |
| " | " | 1876 | 598,197½ | " |
| " | " | 1877 | 847,718¾ | " |
| " | " | 1878 | 905,768 | " |
| " | " | 1879 | 841,796 | " |
| " | " | 1880 | 1,473,600¼ | " |
| " | " | 1881 | 1,111,155¼ | " |

The largest herring fishery ever known occurred in 1880, while that of 1881 is the next largest on record, and this latter notwithstanding the unfavourable fishing weather, "caused by repeated gales of extraordinary violence and suddenness; numbers of boats and vast quantities of fishing property were destroyed, while, above all, the loss of life among the fishermen was unparalleled" (Report, 1881, p. 1). With respect to the herring fishery of 1880, the greatest ever seen upon the coasts of Scotland, abundant both upon the west and east coast, the Commissioners speak of it as giving a "yield of such profuseness as greatly to exceed anything hitherto known or recorded of the Scotch herring fishery. In one previous year alone had the fishing amounted to 1,000,000 barrels of herrings, viz. in the year 1874, when the produce just exceeded 1,000,000, the return of that year showing a cure of 1,000,561 barrels; but in 1880 there was added to the million nearly another half million. The mere excess then of 1880 over 1,000,000 largely surpasses the entire herring fishery of Scotland in its earlier years of fishing enterprise, and exceeds the fishery of even so recent a period as the year 1859, the fishing of that year having produced only 457,130 barrels of herrings. It is also to be observed that in 1880 the produce of the east coast fishing alone largely exceeded the produce of the entire herring fishery of Scotland in any previous year" (Report, 1880, p. 1).

The method of preparing the fish at the Scotch stations, which is known as the British white herring cure, consists, as Mr. Holdsworth tells us, "simply in packing the herrings with a certain proportion of salt in well-made barrels, where they remain until they are required for consumption. The process, however, needs considerable care, and it is considered important that the curing should be commenced as soon as possible after the fish are caught. No time, therefore, is lost in bringing the fish on shore; and after having been measured in a stamped vessel holding 36 gallons, and known as a 'cran,' they are at once taken in hand by the gutters, who perform their duties with a marvellous rapidity only to be attained by considerable practice. This part of the work is almost entirely done women. As soon as the fish have been gutted—and is purpose it is necessary to make only a small opening near the head—they are placed in large troughs containing salt, where they are well "soused" or stirred up, so that the salt may be applied to their whole surface. The fish are then carefully packed with alternate layers of salt in barrels of regulated size, and after remaining fifteen clear days in the pickle, the barrels are filled up as necessary, and finally closed. If, however, they are intended for exportation to a warm country, the barrels are repacked in the same manner as at first.

"The cured herrings are separated into four classes, consisting of 'full,' or fish having large milt or roe; 'maties,' or fat fish, and with the roe undeveloped; 'spent,' or shotten, those which have recently spawned; and 'mixed,' consisting of inferior and perhaps broken fish. The whole process of curing is carried on under the supervision of the Scotch Fishery Board, or to speak more correctly, the Board of British White Herring Fishery. This mode of cure is required by Act of Parliament to be carried out under inspection; and if the result of the cure come up to a certain standard of excellence, the curers can have, on payment of fourpence per barrel, a Government brand placed on each barrel so approved. The branding is quite optional on the part of the curer; but in either case the curing must be open to inspection, and barrels of a particular size must be used for packing the fish in. It is one of the anomalies of the system, however, that although it is absolutely forbidden to use barrels of other than a certain size, there is not the slightest restriction as to the quality or condition of the fish to be packed in the barrel, so long as the Government brand is not desired for it. Any refuse fish may be cured and packed, but the barrel must be of a certain size" ('Deep-sea Fishing,' pp. 294–296) Russia, Germany, Holland, and Belgium, are the countries to which the white cured herrings of Scotland are principally sent.

The total quantity of herrings exported for the year ending December 31st, 1880, were to Ireland, 32,481¼ barrels; to the Continent, 976,300½ barrels; to places out of Europe 1028½ barrels.

The number of barrels cured was 1,473,600¼, and the grand total number exported was 1,009,811½. The total quantity of herrings branded during the same year was 689,286 barrels. The commissioners (Sea Fisheries Report, 1866) recommended the total abolition of the branding system. A select committee of the House of Commons in March 1881 recommended that the present system of branding should be continued, and that the surplus fees should be appropriated to the improvement of piers and harbours, &c. The branding system gives satisfaction to most of the Scotch curers, bringing considerable fees, is a recognised mark guaranteeing a certain standard of excellence to the continental buyer, and facilitating sale to the exporter; this being the case, it is best to "let well alone," and allow the system to continue in force.*

The celebrated Yarmouth bloaters are selected from the finest herrings; they are well washed in baskets which are shaken in tubs of salt and water, each fish being separately pickled to ensure thorough permeation of the liquid; 29 lbs. of common salt to about 71 lbs. of water, in which the herring will float. "By keeping them wholly immersed by battens of wood held down with bags of salt, the latter is gradually dissolved, and retains the solution at its proper density, both at surface and at bottom. The vats are arranged with holes and taps, to run off the pickle when the fish are sufficiently salted. This is when they become stiff or rigid on handling. The fish are now strung by the heads on wooden rods, and hung in a current of air until removed to the chimney, where they are smoked with two parts oak, two parts beech, and two parts 'fern or grass turfs,' for from twelve to eighteen hours, according to the size of the fish and the steadiness with which the smoke has been kept up. These bloaters only keep four to five days, and are best kept for use hanging in currents of air." The bloaters intended for export to the Mediterranean are more highly cured, being kept from four to six weeks before packing in barrels; one barrel of salt serves for three barrels of herrings (see Mr. W. Anderson Smith's essay, 'Fish and Fisheries,' p. 99). Kippered herrings are first pickled in the usual manner, then wiped dry, and split open at the back till about one inch from the tail, so as to leave the bone bare; the gills and insides are removed, and the fish brushed with salt water. They are then hung by the shoulders for a night in a current of air, and afterwards smoked until light brown or chestnut. They are always packed face to face with oiled paper between each pair, to keep them from contact. They do not keep very long. "In all large curing establishments drying is now facilitated by artificial currents of air from fans or Root's blowers" (Anderson Smith).

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* There is a good paper by Mr. W. Simpson Miln, advocating the continuance of the brand system, in 'Fish and Fisheries,' p. 236.

"Red herrings are prepared by curing still more than bloaters. They are pickled in a saturated solution of common salt to which half an ounce of saltpetre is added for every pound of salt. When the fish are rigid the pickle is removed, and they are dried for a day or two on spits and then smoked until they are of the proper colour, preferably with oak wood. The first step beyond salting, in the case of the common fishes, is smoking, and the best of all our British fishes are no doubt those so treated. Smoke-drying is advantageous, not only from the heat of the smoke, but from the pyroligneous acid and kreosote disengaged in innocent quantities, the kreosote coagulating the albumen of the fish."

The wholesale price in the London market for herrings is from 25*s.* to 30*s.* or 42*s.* per box in the autumn and winter months, when they are in best condition. Kippered herrings fetch from 2*s.* 9*d.* to 4*s.* 6*d.* or even 6*s.* per box. Bloaters are quoted at from 1*s.* 9*d.* to 2*s.* 6*d.* or 2*s.* 9*d.* per box.

*Names.*—The Latin generic name *Clupea*, whose derivation would point to something bearing a resemblance to a shield (*clipeus*, *clupeus*), was given by Artedi to the herring and its allies, and is so used to this day. I can find only one reference to a fish called *clupea* in the classical authors, viz. in Pliny (ix. 17), who speaks of a very small fish under that name, which attaches itself with wonderful tenacity to a certain vein in the throat of the *attilus* (sturgeon), and kills it by its bite. Cuvier supposed that a lamprey (*Petromyzon*) was intended. The herring does not occur in the Mediterranean, and was not known to the Greek and Latin authors; those writers who have identified the herring with the Greek *chalcis* are clearly in error. The sardine or pilchard, the anchovy and the shad (*Clupea alosa*), were known to the ancients, but not the herring.

The word *herring*, mid-English *hering*, the Anglo-Saxon *hærineg*, Dutch *haring*, German *häring*, is most probably to be referred to the Teutonic base *harya*, "an army," in allusion to the vast shoals or armies which herrings form, similarly the Hebrews spoke of a horde of locusts as "an army" (see Joel ii. 11, 25); and perhaps the provincial name of *rooks* as used for herrings has reference to their "huddling together" (Halliwell's 'Dict. of Archaic Words,' *s. v.* "Rook"); and another provincial name given by Satchell, "sodger" (soldier), has doubtless the same explanation. The name of *capon* used in Kent to denote a red herring, is difficult to explain. The word *matie*, used to designate a herring in which the roe or milt is undeveloped, admits of easy explanation; it comes to us from the Dutch *maatje*, a "comrade," "mate," not from *meisje*, "a girl or maiden," with which Prof. Huxley compares it. The Dutch divided their herrings into three classes, (1) *voll*, full of roe; (2) *maatjes*, with undeveloped roe; and (3) *ijdel*, "empty or shotten;" the *maatjes* therefore denote herrings of one size and condition, *mates* in fact, for the English and Dutch words are identical, all of the same size, "equals" in contradistinction to the "mixed" class of the Scotch curers. The *maties* therefore do not denote young maiden herrings which have never developed roe or milt, but herrings of any age in which the roe or milt is as yet not found, or in which it is very immature.

*Bloater* originally meant a soaked fish; and Wedgwood aptly compares the Swedish *blöt-fisk*, "soaked fish," from *blöta*, "to steep" or "soak." In Icelandic the expression *blautr fiskr*, literally "soft fish," was used for "fresh fish" in distinction to *hardr fiskr*, "dried fish" or "stock fish," so common a food among the Icelanders. The derivation of the word points to the fact that the mere process of steeping fish in salt water preceded that of smoking, with which idea we now always connect the word bloater. Who first originated the capital idea of curing fish by smoke one cannot say. The ancient Greeks and Romans had their salt fish and smoked hams, but I can find no mention made of smoked fish. Perhaps the art of curing herrings and other fish by means of smoke was not much practised before the reign of Queen Elizabeth, in whose time allusions to smoked herrings occur. In John Russell's 'Boke of Nurture' I can find no reference to smoked fish; for salt herrings mustard is recommended as the metest sauce. But in Beaumont and Fletcher we read, "I have more smoke in my mouth than would blote a hundred herrings ('Isl. Princess,' ii. 5); and in Ben Jonson ('Masque of Augures,' 17th speech), "Why, you stinke like so many bloat herrings newly taken out of the chimney." Pilchards under the name of *fumados*, now corrupted in Cornwall to "fair maids," were imported in Queen Elizabeth's time into Spain. Shakspere speaks of "shotten herrings and dried herrings"; but he makes no allusion to bloaters or smoked herrings. Whether the Dutchman, William Beukelen or Beukeljzoon, who has the credit of first inventing the art of pickling herrings, and whom the Emperor Charles V. held in such veneration for the service he thus did to mankind as to honour his tomb with a visit, applied a smoking process or not, one cannot say; but the old story that the word *pickle* took its name from its inventor, *Beukelen*, is, as Prof. Skeat remarks, an evident fable. The conversion of white herrings into red herrings was, like many other discoveries, probably accidental. Nashe, in his 'Lenten Stuffe,' says that a fisherman having hung up some herrings in smoke, which were as white as whalebone, found them, when he next looked, red as lobsters.

The word kipper literally means a "spawner," Dutch *kippen*, "to hatch;" it more particularly denotes a salmon after it has spawned; and as it is very inferior and almost worthless food when eaten fresh in that condition, it was cured; hence, the same curing process having been adopted for the herring, the same term was used.

Other terms in use having reference to herrings are an," "last" and "warp." The herring computation-table on the east coast of England is as follows, according to Holdsworth.

4 herrings = 1 warp.
33 warps = 1 hundred = 132 fish.
10 hundred = 1 thousand = 1320 fish.
10 thousand = 1 last = 13,200 fish.

The word *last* literally denotes a "load" or "burden;" Anglo and Saxon *hlæst*, "a burden," from *hladan*, "to load." Dutch and German *last* from *laden*, "to load." Halliwell gives the following explanation: "a measure. It is eighty bushels of corn, twelve barrels of fish, fourteen barrels of pitch, tan or ashes, twelve dozen hides or skins, twenty thousand herrings, twelve sacks of wood, twenty dickers of leather, &c. 'White herrings a laste, that is to saye, xiij. barrelles.'—Ord. and Reg. p. 102." Cran is Scotch, from the Gaelic *craun* = a "barrel," 36 gallons. "*Warp* perhaps denotes a *wrap* or small bundle (of four fish)."

Satchell gives the following provincial names of the herring: *blue-back*, *capon*, *cob*, *corphun*, *herring-bairn*, *herring-cob*, herring-fry, *Norfolk-capon*, *rooks*, *red-herring*, *sill*, *shotten-herring*, *sodger*, *tow-blowen*, *Yarmouth-capon* *yawlings*, *white-bait*, *white-herring*.

The blue-back of course refers to the colour of the herring's back. Has *capon* allusion to a fat herring in its *matie* state? *Capon*, as applied to a castrated pullet-cock, always suggests fatness. *Cob* is given by Halliwell as the name of a "young herring," with which we may compare the word *cob* as applied to a short-legged, stout, little horse. *Corphun*, explained by Halliwell simply as "a herring," is obscure. *Sill* denotes the young fry, and possibly may refer to the enormous masses into which they *swell;* for the root of *sill* = "the timber at the foot of a door or window," is that part which rises or swells above the rest. *Tow-blowen* is a "blown herring"—Suffolk. Has *yawlings* reference to herrings brought on shore by the small boats or yawls? On the subject of *white-bait* a few words are necessary.

*White-bait.*—The question as to what fish is really designated by the above name has long been a subject for discussion. The white-bait sold in the markets and shops throughout the country, on inspection manifests itself as a glittering collection of small fishes, the greater proportion of which are evidently at a glance clupeoids of some kind; but mixed with them are to be found young fishes belonging to families differing from that of the herring; such as young sand-launces, three-spined sticklebacks, young weever or sting-fish, gobies (*Gobius minutus*), small pipe fishes, &c., &c. Nevertheless the bulk consists of one kind of fish evidently belonging to the Clupeidæ. According to the late Mr. F. Buckland, white-bait "was first introduced into the London markets by one Mike Murphy, not fifty years ago [Buckland's remark was made in 1873], and the place where it was first eaten was the Artichoke Tavern at Blackwall" ('British Fisheries,' p. 120). This is, however, hardly correct, because Pennant in his 'British Zoology,' edition 1812, thus speaks of the white-bait herring: "During the month of July there appear in the Thames, near Blackwall and Greenwich, innumerable multitudes of small fish, which are known to the Londoners by the name of white-bait. They are esteemed very delicious when fried with fine flour, and occasion during the season a vast resort of the lower order of epicures to the taverns contiguous to the places they are taken at" (iii. p. 465). However, Mike Murphy may have done something to push the sale of white-bait in the London markets. For many years the higher order of epicures or fish-fanciers has been in the habit of consuming large quantities of these little fishes. Yarrell quotes from the *Morning Post* of 10th September, 1835, as follows: "Yesterday, the Cabinet Ministers went down the river in the Ordnance barges to Lovegrove's West India Dock Tavern, Blackwall, to partake of their annual fish dinner. Covers were laid for thirty-five gentlemen." White-bait dinners are now-a-days an "institution" everywhere during the summer and autumn seasons. I have been assured by one of the most extensive dealers in fish in the Bilingsgate Market, that the white-bait of to-day is a very different fish from the white-bait of twenty or thirty years ago. Mr. Sproston informs me that the white-bait several years ago was quite distinct from the fish which forms white-bait now. He says that the fishes did not resemble sprats or herrings at all, but that they were cylindrical and more like small eels, but yet distinct from that fish. These fish are not caught now in any quantities. The little goby (*Gobius minutus*) may perhaps be suggested, but the question of identity must be left undetermined. Pennant's white-bait appears to be a young herring, and such was the dish sought after by the lower order of epicures of whom he speaks. With respect to the fish now known as white-bait, there is not a shadow of a doubt that it is the young herring in nearly all cases; but occasionally young sprats form the white-bait of commerce. I have examined nearly a hundred samples of white-bait from various parts of the coast, and from the London, Liverpool, Birmingham and other markets, and almost without an exception they proved to be young herrings. I find recorded in my note-book one only instance of "white-bait" proving to be young sprats; this sample was caught off Crosby, near Liverpool, in March 1881, and labelled white-bait on a bottle in the Liverpool Museum. But how can fishes so similar as a sprat and a herring be distinguished, and can those marks which characterise the adult forms and serve to separate them, be depended on for diagnosis in the young fry of the herring and the sprat? The answer is easy to give in the affirmative. One of the several characters which separate the two species *Clupea harengus* and *C. sprattus* will be found to be always reliable for diagnosis in fishes not more than one and a half inch in length. The herring has a patch of teeth on the vomer, the sprat has no teeth on the vomer. This mark of difference has been excellently shown by Dr. Günther, and I have no hesitation in saying that it is constant at all ages of the herring and sprat, from young fishes of not more than about one and a half inch long. There are other differences between young sprats and young herrings of the same size; the next best distinguishing mark is the more strongly serrated character of the abdominal scales in the sprat than in the herring, but this point of diagnosis between the two species is not so conspicuous in the young as in the adult. Dr. Günther has some admirable remarks on the dentition of the genus *Clupea* in the seventh volume of his work 'The Catalogue of the Fishes in the British Museum,' a standard work of reference to all persons who take scientific interest in this subject. He says, "No more unfortunate method could be adopted for the systematic arrangement of a group of animals than one based exclusively on differences in an organ which has become rudimentary in that group, and consequently subject to even individual variations . . . . In Cuvier's genus, *Clupea*, the dentition is dimental; the teeth in the jaws are more or less com- ely lost in a number of individuals, either by accident or age; those on the tongue, if present, are a more constant part of the dentition; yet there are numerous species in which the lingual teeth are few in number, and as readily lost as those in the jaws. Nearly the same may be said with regard to the teeth in the palate, and innumerable instances may be met with in which it is impossible to say whether a certain bone has been provided with teeth or not. However, in the few species provided with an ovate patch of vomerine teeth these are constant." It seems to me remarkable that Möbius, in his paragraph on the comparison of the herring and the sprat (U.S. Report, Commission, p. 545), has omitted to notice the presence or absence of the vomerine teeth in these two species of fish. Mr. George Sim also makes no allusion to this character. Günther states that all the examples of white-bait he had examined were young herrings; and of white-bait as a distinct fish he says, "this is a purely nominal species, introduced into science by Yarrell and Valenciennes in deference to the opinion of fishermen and gourmands."

*Comparison of the herring and the sprat.*—The above remarks relate only to the dentition of these fishes, but the presence or absence of the vomerine teeth is of itself, I think, sufficient to show to which species the young white-bait belong. The vomerine patch is quite evident, under the magnifying power of a lens, in little fish not more than about an inch in length; but to examine properly it is often necessary to soak in spirits for some days, and afterwards to dry the specimens; or simple drying will suffice. The flesh and skin and mucus shrivel or disappear, and the little band of sharp teeth stands distinctly out. There are, however, other differences, the most marked of which may be mentioned here.

(1.) Position of the dorsal fin.*

Its origin is a little distance before that of the ventral, in the herring. Its origin is a little distance behind that of the ventral, in the sprat. (Plate IX.)

(2.) The abdominal scutes or serratures are more decided and conspicuous in the sprat than in the herring; it is, however, quite incorrect to say that the herring has no serratures on the belly (Sim) at any stage of its existence; the serratures in young herrings of three or four inches in length are evident, both to the eye through a lens, and to the touch of the finger.†

(3.) The relative number of vertebræ.

In the herring there are about 56.

In the sprat there are from 47 to 49 only.

Mr. George Sim ('Fish and Fisheries,' p. 29) draws attention to an additional point of difference between the herring and the sprat, in that the former has "well developed articular processes on a number of the vertebræ; these processes arise from the base of the transverse processes of each vertebra, pointing towards the head of the fish, and are of a long needle-like form, whilst in the sprat the same organs are merely represented by short knobs." Mr. Sim gives a figure of a herring's skeleton showing the processes to which he alludes. These processes, which are accurately described, are the *zygapophyses* which in most fishes serve to connect together the neural and hæmal arches; on cleaning a herring's caudal vertebræ and comparing them with those of a cod-fish before me as I write, the

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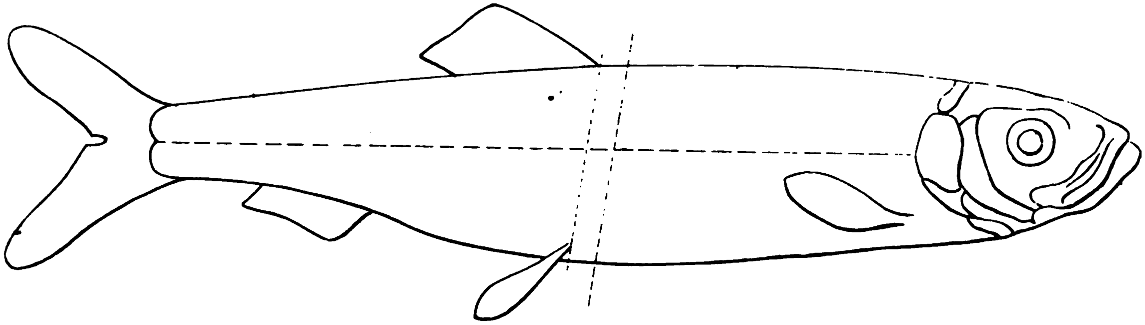
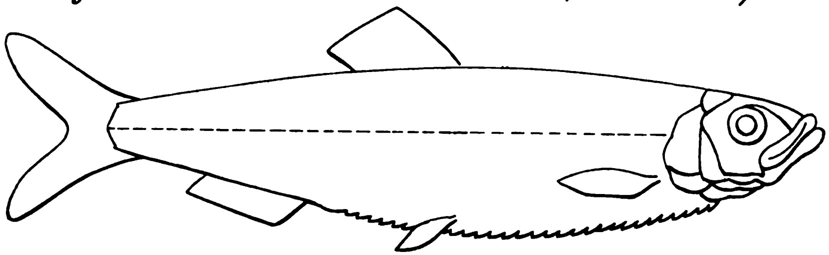
* This relative position, however, is not always well-marked in young specimens; in the sprat the ventral fin is sometimes almost even with the origin of the dorsal.

† Parnell's assertion that "the serrations on the belly are to be found in all young herrings" is quite correct. Parnell was not the man to make fallacious statements.



Outline of Herring from the North Sea
The dotted line in front of the dorsal & ventral fins indicate the places where these fins are found in the Baltic Herring
(showing structural differences in the same species of fish)



Outline from a Sprat from the Baltic
(The abdominal serrature is exaggerated)

processes in question are clearly the *zygapophyses,* which certainly, as Mr. Sim has pointed out, are in the herring extremely long and acicular. Moreover, these hæmal processes in the herring are not true articulations ; they do not connect together the hæmal arches as these arches do in the cod and other fishes ; in the herring they stand out free and independent on each hæmapophysis and have no true articular organisation ; the corresponding processes on the neural aspect have an articulating mechanism. I have not had an opportunity of comparing the herring's skeleton with that of an adult sprat ; in young herrings about 3 inches in length these acicular processes are visible ; in young sprats about 2 inches long I have failed to detect them.

With regard to one species of fish being distinct from another because they contain different entozoa, it would be excessively fallacious to found any arguments upon that fact. Mr. Sim's figure (Fig. 2, No. 3) of an entozoon from the stomach of a herring, seems to be meant for the *Distomum appendiculatum*, Rudolphi, which is parasitic in a great number of fish, and is by no means confined to the herring ; and Diesing ('Syst. Helminth.' ii. p. 166) mentions the entozoon *Ascaris gracilescens* as being found both in the sprat and the herring. Mr. Sim's remark, therefore, that sprats possess a parasite quite different from that of the herring, and that young and old of both species have their own peculiar species, is based on a mistaken notion altogether. Of course it is possible that an animal may possess a parasite peculiar to itself—so far as experimental investigations tend to show—and such evidence may serve to throw additional light on the question of a distinct species ; but such evidence is not very trustworthy, and of little weight. If, for instance, out of a number of clupeoids a certain proportion showed the presence of the epizoon

*Lerneonema spratti* (Plate I.) attached to their eyes, an examination of the specimens would probably prove that the fish so affected was a sprat and not a herring, because so far as we know at present, this epizoon is peculiar to the sprat; but since another species of *Lerneonema*, viz. *L. encrasicoli*, has been found on the body both of the anchovy and the sprat, it would be hazardous to assert that the *L. spratta* was never found on any other fish. The evidence of the sprat and the herring being distinct rests on a most clear and reliable basis, and it is a mistake to try to support that evidence by a reference to their parasitic guests.

*Enemies of the herring.*—"There are few animals," says Ljungman, "which are more defenceless, more persecuted by numerous and dangerous enemies than the herring, and if it were not so extraordinarily prolific it would surely have died out, or would at any rate have ceased to appear in such large numbers as to form the object of fisheries of a vast economical importance." No doubt the herring has a great many enemies; its glittering appearance, its habit of swimming in shoals and frequenting for the most part the surface of the water, all render it an attractive prey to various predaceous creatures, whether seals, whales, porpoises, among mammalia; gannets, sea-gulls, razor-bills, guillemots, divers, puffins and other sea birds; the salmon, cod, mackerel, dog-fish and hake, &c., among predaceous fishes. Enemies prey upon the herring, whether as adults or as young fry; the mackerel is a very decided lover of herring fry, and I have known the salmon to be frequently decoyed into fishing weirs by shoals of tempting young "white-bait." The eel has the bad repute of consuming vast quantities of the deposited ova, and doubtless other guilty of the charge. In what was said of the he garfish, it is quite probable that it is also a dangerous foe to the herring, and attacks its eyes, as it is known to do those of the pilchard and mackerel. Albertus Magnus, in Gesner ('de Aquatil.' p. 410) writes, "Acus piscis (*der Hornfische*) persequitur harengos et perquam damnosus est piscatoribus ut audio ; ego de gladio pisce id potius dixerim." ("The needle-fish pursues the herrings, and on that account is very injurious to fishermen as I hear. I am inclined, however, to think this is rather said of the sword fish.") Confirmatory evidence of the garfish attacking herrings' eyes is needed. Among the enemies to the ova are enumerated parasitic algæ, star-fishes and large crustaceans. Parasitic algæ, I think, may be put nearly out of the question ; with the exception of *Saprolegnia ferax* and its allies, whatever they may be, algal growth in sea water is almost unknown.

Ljungman, however, mentions as an enemy to the herring the "so-called sea blossoms," a kind of salt-water alga (*Oscillatoriæ*), frequent in the Baltic and which often force the herring to seek deeper water. In our English Lakes, notably at Ellesmere, the water is at certain times in the summer quite discoloured by a fresh-water alga whose name at present has escaped me ; the fishermen there call this state of the water a "breaking up." Certainly the fish are affected by it to some extent, for pike refuse to run at a bait, and perch will not take a worm. I doubt, however, whether this causes any real mischief to the fish, beyond a temporary sickness.

Ljungman also speaks of a kind of faintness to which herrings are sometimes subject: He says: "The herring often consumes small and generally very oily aquatic animals in such enormous quantities that its whole inside is filled with a putrefying, stinking mass of animal matter, so that it is not fit to become an article of human food. And this condition of the herring has by some authors been considered as a sickness; as such even that certain faintness has been explained, which sometimes overcomes the herring after spawning to such a degree that it is helplessly tossed about by the waves. This very circumstance was mentioned in the dispute regarding our fishery laws, when it was used as proof of the assertion that the sea herring had been driven away from the coast of Bohuslän. This faintness has doubtless been much exaggerated, but cannot be denied entirely, although it has not been observed in all places where herrings are found. It may possibly be ascribed to the diminution of vital strength produced by spawning, or by a long period of scanty food, or, according to Gisler, by long and violent storms and otherwise unfavourable weather. It is likewise supposed that herrings, like other fish, occasionally suffer from epidemics" (U. S. Report, p. 507. 1879 (1882)).

With respect to the prolific nature of the herring and the enemies which prey upon it, comes the question, are herrings more numerous than other fishes? The roe of the herring has been estimated at 25,000, that of the lump-fish at 155,000, of the halibut at 3,500,000, and that of the cod at 9,344,000; from this it would seem that the herring has many times fewer eggs than any of the fishes just named. The herring during its whole life has probably more enemies than nearly all fishes, and yet the captures of these fishes every year around our coasts are so amazingly large that it is almost impossible to estimate the number caught. The quantities of any kind of our sea fishes which are taken by human means are no criterion of the relative quantities of the various kinds which do actually exist in our seas. We are able to catch vast quantities of herrings because they shoal in prodigious numbers and often swim in comparatively narrow areas as in Loch Fyne. Other fishes may be, and probably are, more numerous, but these numbers are distributed over wide areas, and the chances of capturing them is therefore far less certain. Let the various enemies of the herring eat to their heart's content, great as must be the destruction of the fish, especially in their early fry stage, by the natural agencies almost incessantly at work, the work of diminution is inappreciable; and if this be so with respect to those natural enemies in the air or the sea, how almost infinitely small must be the destructive agencies employed by man, and how foolish and mistaken the notion that legislative prohibitive measures should be passed with a view to increase the yearly products of the great sea's harvest. Of course care should be taken not to scare away the fish from any particular locality by any unnecessary acts; fishermen generally believe that the herring is a fish easily frightened, and that at any sudden and loud noise it will quickly change its course. I doubt, however, whether herrings are more easily scared than many other fishes, which are generally timid and will dart rapidly away from that which frightens them, excepting during the spawning season; but they soon return again to their old places.

Ljungman tells us that herrings as a rule exhibit great terror at the seine-net, and it is often very difficult to catch them in this manner. On this account the fishermen ply their vocation at night[*] when the net cannot be seen by the fish, or else, if day-seining is practised, more success will attend labour if the water be turbid either from storms or from a constant influx of muddy river water. And this is true of all kinds of fishing. Trawlers always have better luck when the water is not too clear. But the nervous susceptibilities of herrings are not aroused by human means alone; "when a cod-fish," we are told, "gets into a seine with the herrings, it creates such a terror among them that they rush against the sides of the seine with the fury of despair and often burst it.

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[*] One reason why herrings are found near the surface at night is, doubtless, because many of the small marine crustacea on which they feed are found near the surface at night, and recede towards the bottom on the approach of daylight. (See Brady, 'British Copepoda,' i. p. 10.)

Among the natural enemies of the herring one must not forget to mention parasitic entozoa, to which allusion was made above. Diesing ('Systema Helminthum,' ii. p. 396) enumerates six species of intestinal worms; two kinds of *Distomum*, one of *Agamonema* and three of *Ascaris*. As a rule I do not attribute very much injury to any kind of fish from the presence of intestinal worms, unless, which sometimes happens, these creatures occur in great numbers, when indeed, as in the mackerel disease (see under Mackerel), they may cause quite an epidemic among the affected fishes and a serious loss of food to the people. Any one who has opened fish with any attention must have noticed how frequent is the presence of intestinal worms of various kinds; indeed it is rare to meet with complete exemptions. The stomach and intestines of a salmon, for instance, may contain several specimens of a long *Tænia*, or tape-worm, and nothing in the world else but a slimy mucus, but the flesh of the fish shall prove firm and well-flavoured notwithstanding. But where the number of parasitic guests is great, the flesh of the fish becomes sadly deteriorated. I have taken large coiled masses of *Agamonema Fabri* from the liver and viscera of the John Dory; the flesh of the fish was soft and thin, and I should not have liked to have eaten of it. Sometimes the herring's peri-visceral cavity swarms with some kind of *Agamonema;*[*] one I have just measured is nearly an inch in length—it was taken with an entangled mass of the same worm from a "shotten" herring on the 26th of October 1882; several of these shotten herrings were similarly infested and were unfit for food. Mr. George Sim's "great unknown," which from his description and figure[†] seems to be the *Distomum appendiculatum* of Rudolph (see his 'Entozoorum sive Vermium Intestinalium Historia Naturalis,' i. tab. v, fig. 2; ii. p. 400), when present in great quantities is doubtless injurious to the fish. Diesing enumerates twenty species of fish which this little creature inhabits besides the herring.

In connection with the sicknesses of the herring, Ljungman speaks of its ability to live out of water longer than is generally supposed. The old saying, "dead as a herring," is usually referred to the speedy collapse of that fish on taken out of the water. "It has been said that the herring breathes its last immediately when taken out of the water, and as the cause of this its wide gill-openings were assigned. Neucrantz already opposed this view, and more recent authors have proved conclusively that the herring can live out of water for several hours if it is not exposed to the heat, pressure or any violence. Herrings caught in nets are generally dead when the net is hauled in, and this circumstance has probaby given rise to the opinion that the herring dies as soon as taken out of the water. Herrings caught in large seines live longer, and those caught in bottom-nets or fish-pots live longest. The herring cannot stand any long pressure, and in seine-fishing care should be taken to avoid it, as it may cause the death of many herrings, and by increasing the weight may make the hauling in of the seine difficult or impossible. On the whole the herring must be counted among the least hardy fish, and this applies in a still higher degree to the small herring [sprat]; under favourable circumstances, however, even the small herring may live for half-an-hour after it is taken out of the water." (U. S. Report, p. 507.)

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[*] *Agamonema* is a genus established by Diesing; it represents the *Filaria piscium* of authors, "a name under which several species of asexual nematoid worms have been described; they are found in the abdominal cavity and among the muscles of several marine fishes." (Cobbold, Entoz. p. 407.) From the tendency of these worms to pierce the muscles I consider the various species of *Agamonema* to be amongst the most objectionable form of fish entozoa.

[†] Mr. Sim's figure is that of a dead specimen; the caudal part of the body is shown globose and hides the pointed retractile tail. "The body composed of a number of rings" answers to the epithet *crenatum* of Rudolph and Diesing. I have no doubt that *D. appendiculatum* is the species in question.

*General description.*—I will give the description word for word from Dr. Günther's Catalogue. Those who have paid much attention to these subjects know how accurate are the words, neither too few nor too many, of one of the greatest of living ichthyologists. "The height of the body is nearly equal to the length of the head. Lower jaw prominent, the maxillary extending nearly to below the middle of the eye. *An elongate ovate patch of very small teeth on the tongue and vomer;* palatine teeth, if present, minute. Gill-rakers fine, closely set, about as long as the eye. *Ventral fins inserted below the middle of the dorsal fin.* There are thirteen abdominal scutes behind the ventrals. Operculum without radiating striæ. No dark spot on the ulder." The italics are mine, for the sake of calling tion to those marks in the herring which at once ish it from the sprat.

### THE SPRAT (*Clupea sprattus*).

*Sprattus.*—Willughby, p. 221.

*Clupea quadriuncialis.*—Artedi, Spec. Pisc. p. 17; Gen. p. 7.

*Clupea sprattus.*—Lin. Syst. Nat. i. p. 523; Nilss. Skand. Faun. Fisk, p. 516; Jenyns' Manual, p. 435; Yarrell, ii. p. 197; Parnell, F. of Firth of Forth, p. 162, tab. 35; Günther, Catal. vii. p. 419.

*Sprat.*—Pennant, Brit. Zool. iii. p. 457; Couch, iv. p. 109, pl. 203.

*Geographical distribution.*—The North Sea and the Baltic; North Atlantic coasts of Europe; plentiful on the Norfolk, Suffolk, Essex and Kentish coasts; less frequent on the west coast of England than on the east. It occurs around the coasts of Ireland, sometimes in enormous quantities. In the Firth of Forth and in the Beauly Firth, near Inverness, they are sometimes very abundant and caught in large quantities, but in Scotland, owing to the low prices and the small demand, sprat fishing is not much prosecuted; on the south coast of England large quantities of sprats are taken in the winter time.

*General habits.*—The sprat, like the herring, is a wanderer; it is not generally fished for till towards the autumn; the shoals are capricious in their movements as well as variable in their numbers and the time of their appearance. They are a more daring fish than the herring; Ljungman says that they rush boldly against the sides of the seine-nets, especially whilst it is being hauled in, endeavouring to push through the meshes—in this respect resembling the pilchard. If they are caught in the seine-nets among the herrings, they are generally found sticking in the meshes; they do not try to escape the seine by going into deep water like the herring, except during day-fishing in very clear water. If, however, there is the least chance of escape, they will all rush out as fast as possible. The sprat is more decidedly a surface swimmer than the herring. "During the rich fisheries in the Norwegian boundary-waters, fishermen have reported that large herring and small herring [sprat] were caught alternately by lowering and raising the seine." Ljungman, who has given considerable attention to the habits of the sprat, concerning which, doubtless on account of its comparative unimportance, much less is known than of the herring, states that these two fish, although closely related, cannot well live together, but must rather be considered as mutual enemies. They keep in separate schools, and if both kinds are caught in one and the same seine, as will sometimes happen, this is doubtless caused by the seines enveloping two different schools either whole or in part. Violent storms, however, may occasionally cause the sprat and herring shoals to intermingle. When the two kinds of fish meet, the sprat has invariably to give way to the larger herring, and when large herrings begin to appear in the seine this is considered an unfavourable sign for the sprat fisheries. The large migratory herring is considered dangerous to the sprat, and when occurring in large numbers it is said to chase it away; the fishermen on the northern coast of Bohuslän, therefore, do not like to see this herring make its appearance." (Report, U. S. p. 508.)

*Food of.*—From the small size of the sprat and its very little mouth its food must consist of exceedingly minute creatures, of which small crustacea as the copepoda form a large percentage, especially of the young individuals. I have found the remains of small flies or gnats in their stomachs, and this one would expect in the estuaries from the surface habits of the fish. Small particles of sand and mud I have also found ; these, held in suspension in the water and containing decomposed organic matter in a comminuted form, would freely find their way into the sprat's mouth and stomach. Floating ova and small surface fry are doubtless consumed in large quantities by a shoal of sprats.

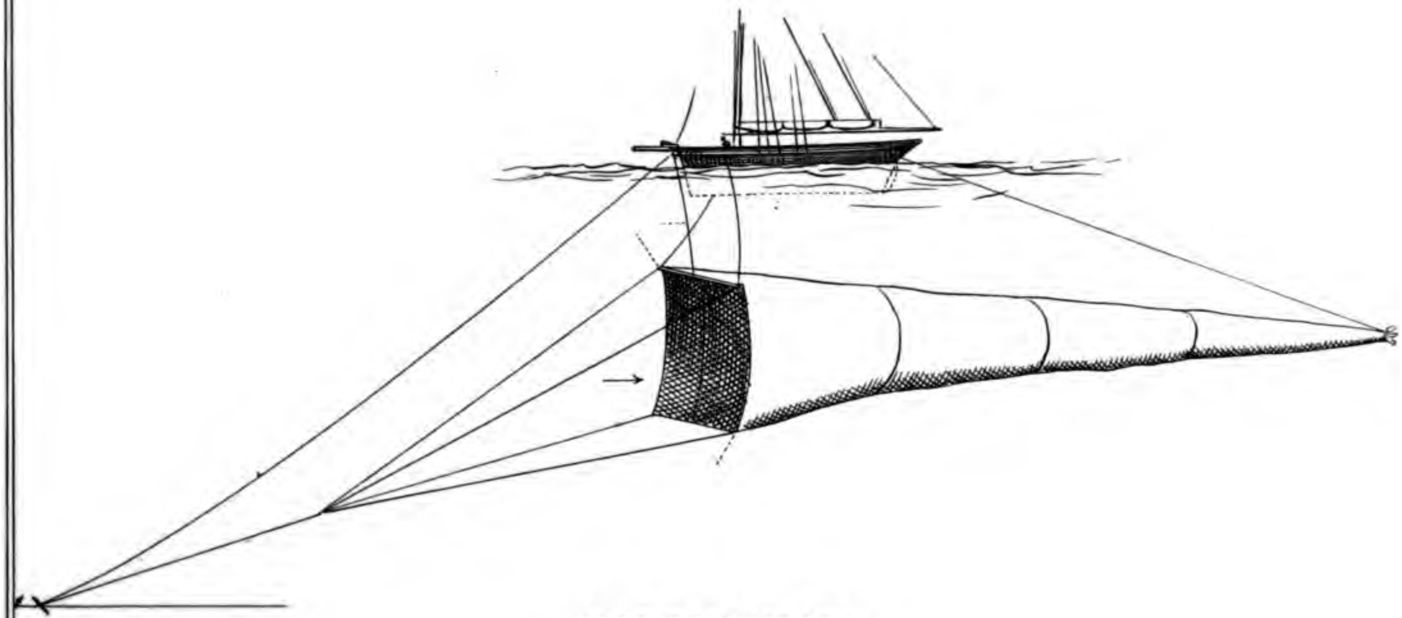
*Spawning.*—Like the herring, the sprat spawns at two different periods of the year ; they have been found full of roe in June, also in January. The Torbay fishermen say that sprats are full of roe in November and December, which demonstrates a winter spawning, and Mr. Day has lately been able to confirm the fishermen's statement, having found in specimens sent to him from Cornwall on the 17th of January, 1881, fully developed ova, and similarly forward milt. There is, therefore, probably to some extent dependent on the locality, a winter spawning time as well as a summer one (see Day, in Journal Lin. Soc. xv. p. 318, 1881, Sept.). Unfortunately, we know nothing, I believe, of the mode of deposition of the ova of the sprat. Do the ova float, as it is supposed those of the pilchard do, or do they sink and form at the bottom a conglomerated mass ? We know that sprats spawn in the summer, because Yarrell found roe well developed in specimens from the Dorsetshire coast in June ; we know that they also spawn in winter, because Day has found full fish in January, and because full fish in the Solent off Ramsgate and the mouth of the Thames are most abundant in the winter time. Sprats appear to be more abundant in the shallow waters during the coldest time of the year. Mr. Holdsworth inclines to the belief that the breeding habits of sprats are more akin to those of the pilchard than to those of the herring, and that these fish not improbably spawn at the surface in summer, generally in deep water, but in winter near the shore. I am disposed to think that the spawning habits of the sprat will be found to be more akin to those of the herring than to those of the pilchard, and that the sprat's ova are formed into masses at the bottom. My reasons for this opinion are because the sprat is more nearly allied to the herring in general form and habits, and is more able to sustain cold than the pilchard, which is more especially a southern and Mediterranean fish, and is not an inhabitant of northern waters at all, and even leaves the coasts of Cornwall and Devonshire for deeper water during the cold winter weather. What influences the immense shoals to frequent our bays and estuaries in the winter? These shoals generally consist of fish whose ova and milt are either mature or tending to maturity. Why are the larger sprats seldom numerous inshore in any quantity except in the winter? Is it not probable that the same motive which impels the full herrings shorewards, at the same time impels the sprats also? Do sprats abstain from food at this time as the mature herring does? I have been disappointed in having failed to secure a quantity of sprats last December, the lot were delayed in carriage and came to me in such a putrid condition that examination was impossible, but some evidence more or less important, derived from the examination of their stomachs at that time, would help to throw light on the cause of the sprat's visits to our shores during the winter. If, as in the case of the herring, sprats abstained from food, then the probability is that, like the herring, the reproductive instinct is the prime factor in the problem, and that the food desire acts only subordinately as in the herring. But speculation is useless; the question her the sprat spawns like the herring, or is a surface-spawner, whose ova float, must wait for actual verification. Shoals of these fish in full condition may approach the shores for the purpose of spawning, and other shoals with immature ova may do the same for the sake of the more abundant food that the estuaries and bays would afford. I have specimens of young sprats caught at Crosby, near Liverpool, in March 1881: they are 2 to 3 inches in length, and these, I should say, are the product of the January or December spawning. Doubtless in the summer months, when food is abundant, they would grow fast. They attain to about 6 inches in length.

*Modes of capture.*—By stow-net fishing, which is carried on both by day and night. The stow-net is thus described in the appendix to the Sea Fishery Commission Report (1863–1865). "The stow-net, as generally used, is a funnel-shaped bag about 150 feet long, with the mouth 30 feet deep and 22 feet wide, the upper and lower margins of the entrance being secured to pieces of timber termed 'balks.' The net is composed of 4 parts, each having a different sized mesh, that of the cod or pointed end of the funnel being very small. When the net is worked, the vessel (at that time called a stow-boat) comes to anchor just at the turn of the tide at some spot where there is an abundance of fish, as shown by the presence of numerous gulls, and by other signs. The net is then lowered to a certain distance below the surface, and the mouth is kept open and facing the tide by means of ropes from the ends of the balks to the vessel and to the anchor, the long net streaming away under the vessel. In this position the stow-boat and net remain anchored for about 6 hours, or until the tide has done, the sprats being carried in myriads by the current through the square mouth of the net, down to the narrow-squared extremity. As soon as the watch on deck observes that the tide is becoming slack, the mouth of the net is closed by the two balks being brought together; this is effected by means of a chain made fast to the middle of the lower balk and leading through an iron loop or strop on the upper one, and thence upwards to a short davit at the bow of the vessel; the net is then brought alongside and secured there with ropes called girdlines. The cod or small end of the net having been hauled on board by the pinion, a rope leading from the cod to the vessel, the end of the net is opened and the fish are measured out, 3 bushels at a time, into the vessel's hold. This mode of fishing, commonly known as "stow-boating," is only carried on from November to February, the time when the sprats enter the estuaries and other narrow waters along certain parts of the coast. The quantity of fish thus taken is sometimes enormous, and it is found that when the shoals are very large they are almost always composed of sprats, but when these fish come inshore in small parties they are generally accompanied by numbers of small herrings, and the young of other kinds of floating fish." (Plate X.)

Sprats are sometimes taken by drift-fishing, as about Ramsgate, Deal and Hastings; this, however, is quite an exceptional method of catching them. "A short train of untanned nets being used from small boats worked by a couple of men, and the produce consisting only of the larger and more valuable fish." (Holdsworth.)

*Quality of flesh.*—Of good flavour, but generally very oily; they are good broiled or fried or baked; dried sprats are sometimes eaten plain, but they are dry and salt. [illegible] he cooked soon after they are caught; in [illegible] nber to the end of February.

[illegible] e.—Small, and sold at a very cheap [illegible] ne of the cheapest and most grateful



STOW BOAT AND NET.
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luxuries of the poor of London. Mayhew ('London Labour and London Poor,' i. p. 69) estimates the number of sprats annually disposed of by the London street-sellers as 3,000,000 pounds' weight, being about one-fifth of the number of pounds consumed as compared with the weight of mackerel. They are sold at Billingsgate by the "toss" or "chuck," which is about half a bushel, and weighs from 40 lbs. to 50 lbs. The price, according to Mayhew, varies from 1*s.* to 5*s.* As a tasty supplement to the poor man's winter food, one can quite appreciate the costermonger's pathetic remark, "Ah, sir, sprats *is* a blessing to the poor!" "I am informed by the best authorities," says Mayhew, "that nearly upon 1,000 'tosses' of sprats are sold daily in London streets while the season lasts. These sold retail in pennyworths, at very nearly 5*s.* the 'toss,' give about £150 a day, or say £1000 a week, spent on sprats by the poorer classes of the metropolis, so that, calculating the sprat season to last ten weeks, about £10,000 would be taken by the costermongers during that time from the sale of this fish alone."

Sprats are a very perishable fish, so that if the catches cannot reach London from the coast in time for next day's market, they are sold at the end of the season at a low rate for manure.

The Essex farmers take a large quantity of them when the boats come in too late for the market trains, or on Saturdays, when, there being no market on the following day, it is useless to send them to London. The supply of sprats, like that of other surface-swimming fish, fluctuates from year to year, and this fluctuation has no apparent connection with the greater or less extent of the catch in the previous season. (See Sea Fisheries Commission, Appendix, p. 6.)

Is there not a field open to the curing of sprats, after the sardine fashion, in oil and tins? Why should not a sprat be just as good as a pilchard thus cured? Mr. W. Anderson Smith, in his excellent paper on "Curing and Preserving Fish at Home and Abroad" ('Fish and Fisheries,' pp. 93–104), understands "that a very important trade in tinned sardines, made from English sprats, is already carried on at Lowestoft." There can be no real reason, one would imagine, why sprats should not thus form an excellent additional item of nourishing food to the consumer of fish. But fashion, that stupid tyrant, is in all matters almost omnipotent, and generally sits, and has sat, on the throne of public taste, often to the injury of the public good for very many years. And so the all-important question, which the enterprising manufacturer must first consider before embarking in a new undertaking, comes to the front, "Will it pay?" "Will the people buy?" The Italian sardines rule triumphant in all the markets and grocery shops in the United Kingdom, and a "Billingsgate sprat" does not sound as well to polite ears as a "French sardine." Of course it is reasonable and fair that the best article should command the best sale. With respect to the Cornish sardine, for instance, it may be doubted whether in point of delicacy of flavour, the English fish is equal to the Mediterranean, and connoisseurs will probably decide in favour of the latter as being much superior. I have seen the sardine manufactory at Mevagissey and witnessed the whole process of the preparation of these fish, and I confess that, though the Cornish tinned fish are very good, I do not think they are quite equal to the imported ones. Mr. W. Anderson Smith well observes t a sardine from the west of France, a small pilchard Cornwall, or a sprat from the North of Scotland, are practically equally good if equally carefully and skilfully prepared. The point in which the English sardines seem to me to fail is the insufficiency of the finest olive-oil, in which our continental neighbours excel. Mr. Anderson Smith has truly said that the great secret of securing superior excellence is the employment of the finest olive-oil, the rejection of all inferior fish and careful preparation. He also notices a small but a very important little addition to the best olive-oil in the shape of a bay-leaf, to impart an agreeable flavour. What vast results may follow smallest causes!

But even if enterprise and outlay of capital were to reward the manufacturer by complete success in being able to offer an article as good in all respects as the French article, he would probably have to wait for some years ere he attained commercial encouragement and success by a profitable sale of his goods, so inveterate and ingrained in human systems are fashion and prejudice, and so long as they are rife we must be content with seeing thousands of tons of food-fish annually disposed of to manure our fields.

*Names.*—The word *sprat*, written in Middle English as *sprot* or *sprotte*, is etymologically connected with the word *sprout*, "a young bird," or "shoot;" hence *sprat* was used for anything small, as in Provincial English *sprats*="small wood." The *sprat-loon* is the "small gull." Willughby considered the *sprat* to be only the young herring, and to this day many people share this erroneous notion. The name of *sprat*="little," had probably reference to the generally accepted idea that the sprat was a small herring. We have already seen that Swedish fishermen speak of the herring and the small herring, meaning by the latter term the sprat (compare below). Satchell gives *garvie*, *garvie-*

*herring, herring-bairn, sprat, sprot;* the two former words are Scotch.

*General description.*—I will give the description from Dr. Günther's Catalogue, italicising those passages which serve to mark the difference between the sprat and the herring.

"Scales deciduous, smooth; the height of the body is equal to, or nearly equal to, the length of the head. Lower jaws prominent, the maxillary extending to somewhat beyond the vertical from the front margin of the eye. *An elongate ovate patch of very small teeth on the tongue, none on the vomer.* Gill-rakers very fine, closely set, rather shorter than the eye. *Ventral fins even with the origin of the dorsal* [or a little in front of dorsal]. There are eleven or twelve abdominal scutes behind the root of the ventrals. Operculum without radiating striæ."

### THE PILCHARD (*Clupea pilchardus*).

*Sardina.*—Belon, p. 161; Rondel. pp. 217, 218; Gesner, p. 822.

*Harengus minor sive pilchardus.*—Willughby, p. 223, tab. P, 1.

*Clupea pilchardus.*—Cuv. Regn. Anim.; Donov. Brit. Fish. iii. pl. 69; Fleming, Brit. Anim. p. 183; Jenyns' Man. p. 437; Yarrell, ii. p. 169; Parnell, F. of F. of Forth, p. 100; Günther, Catal. vii. p. 439.

*Pilchard herring.*—Pennant, Brit. Zool. iii. p. 453.

*Pilchard.*—Couch, iv. p. 79, pl. 201.

*Geographical distribution.*—Occurs in the Mediterranean
the neighbouring parts of the Atlantic, at times in
rdinary numbers; is found occasionally in the
avian seas, as in the Sound, and in the Bohus

Skärgärd. The pilchard is specifically the same fish as the sardine, from which, however, it differs in some slight structural particulars. As a British fish it is chiefly to be found off the coasts of Devonshire and Cornwall, and here alone is there any extensive pilchard fishery. It occasionally strays eastward along the Channel as far as Southampton. Pilchards sometimes appear in large numbers on the south and south-west of Ireland ; and according to Parnell, they have been captured in the Firth of Forth. The pilchard, however, is more decidedly a southern fish than the herring and the sprat, and is not capable of sustaining severe cold.

*General habits.*—Though probably a resident in the waters of our southern coasts, as those of Cornwall and Devonshire, all the year, it is only at certain periods that it frequents our shores in those enormous numbers which are almost proverbial. It is generally about the month of July that the pilchard shoals begin to form, and the fishing in Cornwall begins about August, but September, October and November are the chief months during which the pilchard fishery is carried on. Couch, whose home was almost among the pilchards for a great many years, and whose opinion is always of value on such subjects, tells us that the pilchard is easily alarmed at a noise, and that the firing of a heavy gun at the distance of 20 miles has been known to cause the fish to sink and to disappoint the labour of the fishermen. This is very probable indeed, for the pilchards swim in close, compact bodies, and if their ascertained whereabouts has been provided for in the arrangement of their capture, a sudden disturbance of the fish, causing them to sink into water too deep for the nets, would be most disappointing. It seems that off the coasts of Cornwall and Devon pilchards are most abundant in October and November; about the end of December they disappear; probably they go into deeper water away from our shores, or they may migrate in a more southerly direction. The shoals are not again heard of in any numbers till the following July. Pilchards are therefore a migratory fish. What guides them from deeper waters to the Cornwall and Devonshire coasts in such prodigious schools? Do they, like the herring, come there to spawn? Unfortunately, we are not so certain of the spawning habits of the pilchard as we are of those of the herring. Probably Couch is correct, and the pilchard spawns some way from land. The pilchard spawns certainly in the spring; and I believe that this is the more usual time, although I have found, and other observers have done the the same, that the ova are also well matured in specimens during October; pointing to more than one actual spawning period in the year. Now if pilchards spawn at the surface some way from land, it cannot certainly be necessary for them to seek the land for the purpose of spawning. In surface water in May and the summer months pilchards would find abundant food in the countless swarms of minute living crustacean and fish-fry food which surround them, far away from land. But in the colder months of the year they would not find there that abundant supply. But near the coasts in October they would find that necessary supply of food near the shores. Now comes the all-important question, what as a rule is the kind of food which the pilchard seeks? I have examined the stomachs and intestines of scores of pilchards taken in Devon and Cornwall last October and November, and I find, what I believe has never been definitely noticed before, that the chief food of pilchards at this time consists of *Diatomaceæ*. The whole stomach and intestines are loaded with diatoms, and mixed with these are sometimes a certain quantity of minute entomostraca (copepoda); this algal food they would find either fringing the laminaria or other sea-weeds, or forming a scum on the ground near the coast, growing abundantly all round our coasts. The food-seeking instinct, therefore, in the case of the pilchard seems to be the motive power which brings this fish to our shores in October till December. Why do they leave our coasts, apparently so decidedly and suddenly? Like many other sea-fishes, they find the temperature of the shallow coast waters too cold for them in the winter months. Being a Mediterranean and a southern fish, the pilchard is especially susceptible of cold; hence, it seeks a more congenial climate in warmer latitudes, or, as is more probable, in deeper water, beyond the influence of atmospheric influences. In the pilchard then, I believe that its periodic visits to our southern or south-western shores are prompted hitherwards by the search for suitable food, such food being the algal forms of diatomaceæ and minute copepoda, which are more abundant near the shore than far from it in the late autumnal months, and that its departure from our coasts into deeper water is prompted by the temperature. Pennant imagined that the pilchard, like the herring, had a winter retreat, and that its motives for migrating were the same.

*Food of.*—In all the specimens examined by myself in October, 1882, at Brixham and Mevagissey, I found, as already stated, quantities of diatomaceæ, with occasional quantities more or less of copepoda. These the fish would obtain from the surface of the water, or from the bottom amid ooze, or from algæ and other submerged objects of diatomaceous food; they would find plenty also in the stomachs of various gelatinous Tunicata, such as *Aplidium*, *Polyclinum* and *Amœrœcum*, which consume quantities of floating diatomaceæ; the stomachs of these creatures often afford quite a harvest of material to collectors of these microscopic objects. Couch speaks of the contents of pilchards' stomachs as containing nothing besides "a pulpy mass of what may be vegetable substance;" but in some instances, he found "vast numbers of a shrimp-like creature," on which the pilchards had been feeding to repletion. The pulpy mass I have shown to be *diatomaceæ.** In the spring I have found the stomachs of pilchards to be full of the copepod *Harpages typicus*—male and female.

*Spawning.*—As already mentioned, pilchards spawn in spring or early summer, and this is the general time; it is, however, possible that some fish spawn in the autumn, but I do not think that this is the usual time. I have just received an interesting letter from Mr. Matthias Dunn, of Mevagissey, Cornwall, a gentleman whose acquaintance I deem myself fortunate in having been able to make; an excellent and close observer of facts and one very cautious in his conclusions unless based on reliable evidence. On my enquiry of him whether he considered the late Mr. Couch's opinion, that the pilchard spawn floated in a tenacious connected mucus, to be borne out by his own observations, Mr. Dunn writes:—"It is seldom that Couch is in error, but with regard to the pilchard spawn he certainly made a great mistake, and I can well understand how it was done. I believe he saw the pilchard spawn from Polperro hills, and trusted to the statement of others, and that they misled him. What I believe to be pilchard spawn is to be seen along our coasts the last week in June; every globule is disconnected and free from its neighbour; on warm sunny days the spawn rises to the surface of the sea, and if the wind is blowing gently shorewards, it will be seen collected close to the rocks in vast quantities, colouring the sea on its surface like yellowish brown paper, for miles in extent; but it is not connected, and only collects like floating sea-weed on the edge of the water where the tide changes, or by the sea-beach on the land; it has nothing sticky or gluey about it; still, after all, this may not be pilchard spawn. I have tried to hatch it out these two years, but so far have failed. This fish spawns about twenty miles from land, and it is rather a wonder how it gets so close to shore. I once got a pilchard to spawn in a bucket of water, the spawn floated and was like the spawn I have described. The pilchard spawn is a shade smaller in its globular ova than the herring spawn." There seems to be little doubt that Mr. Dunn's floating ova were those of the pilchard, but still absolute proof is required before one can be absolutely certain on this point. It seems pretty clear also that Couch's floating ova "of the thickness of brown paper," extending several miles in length, are also pilchard spawn, but that this latter gentleman was in error in attributing to the spawn a tenacious jelly-like consistency. As the pilchard takes abundant food during the autumn and early winter months when it is found on the coasts of Cornwall and Devon, and as the herring is known to be an abstainer from food at its time of spawning, and as other fish likewise are more or less abstainers at spawning time, it is *à priori* probable that the pilchards' migrations coastwards are not mainly for spawning purposes; and as it is pretty certain that they spawn twenty miles or so from the land, a shoreward journey cannot be necessary for that purpose; hence it may fairly be assumed that the food-instinct directs their movements northwards and the cold of winter drives them away from the shores into deeper and warmer water.

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* *Species of Diatomaceæ noticed in a Pilchard's stomach and intestine:*—

I sent a small bottle containing the contents of a pilchard's stomach and intestine to Mr. Laurence Hardman of Birkenhead, a gentleman well versed in the diatomaceæ. He has kindly examined these things for me, and has sent the following report: "A very large percentage of the diatoms, probably more than 90 per cent., are (1) *Coscinodiscus eccentricus* and varieties. The next most abundant species is (2) *Podosira maculata.* These two diatoms have frequently been found in the stomachs of Pectens, from the south of England, especially on the coasts of Sussex, Hants, and Dorset. Following these perhaps the most abundant diatom is (3) *Triceratium alternans;* next (4) *Orthosira marina*, this previous to being boiled in acid was in filaments, but now the valves are all separated. All the other forms I have met with beyond these are very sparse, I therefore note them in alphabetical order, without reference to their comparative numbers. (5) *Actinocyclus undulatus*, (6) *A. crassus*, (7) *Biddulphia aurita*, (8) *Diatoma elongata*, (9) *Dictyocha fibula*, (10) *Grammatophora marina*, (11) *Pinnularia cyprinus*, (12) *Navicula?* specimen very small and pandusiform, (13) *Pleurosigma angulatum*, (14) *P. transversale*, (15) *Rhaphoneis ?* species (probably *rhombus*), (16) *Rhizosolemia styliformis*, (17) *Stauroneis pulchella*, (18) *Surirella fastuosa*, (19) *Zygoceros rhombus*, (20) *Coscinodiscus radiatus*, (21) *C. lineatus.* I should also notice that there are several varieties in what I call *Coscinodiscus eccentricus;* some might be considered *Odontodisci* from their spinous margins, and others have marginal or rather sub-marginal processes or tubercles. They may probably belong to the genus *Heterostephania* (Ehr.), or the genus *Perethyra* (Ehr.). There may probably be other species besides those enumerated."

Of the growth of the pilchard I believe nothing is definitely known. It attains to eleven inches, the ordinary size is from seven to nine inches in length.

*Modes of capture.*—By the seine and by the drift-net. (Some account of the mode of using the seine-net has been given when speaking of herring fishery.) It has been found by experience that the pilchards first strike the north shore of Cornwall, a little above St. Ives, and then follow the line of coast southwards, and this generally takes place during particular months of the year. When this season has come round, men bearing the title of "huers" are stationed on ls and other suitable situations to look out for the

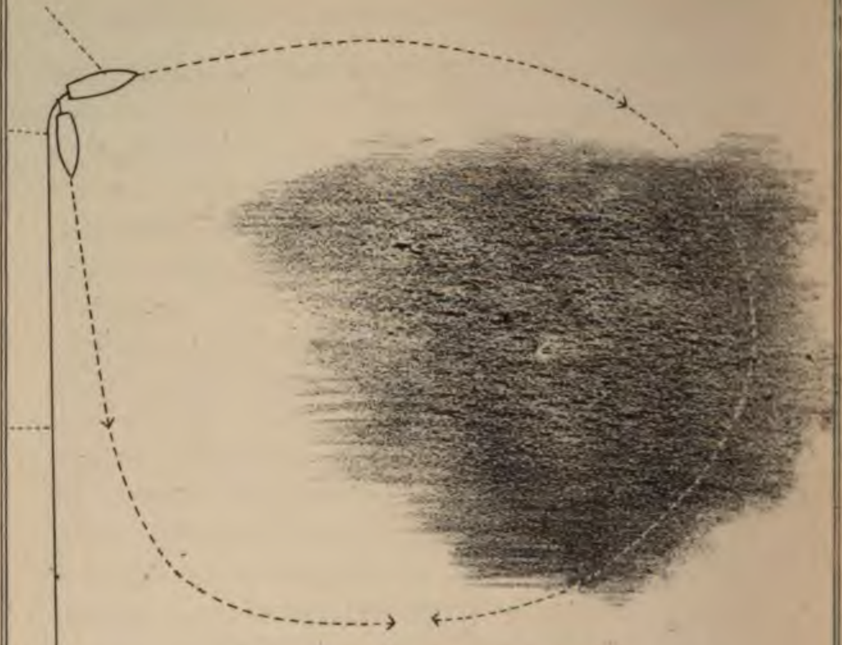
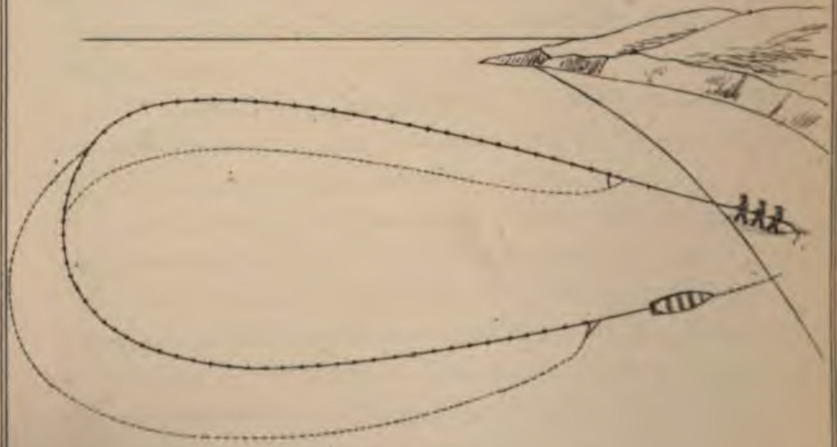


DIAGRAM OF PILCHARD SEINING.



GROUND SEINING.
*Report of the Commissioners 1866.*

expected shoals and by signals to point out to the fishermen in the Bay the direction which the fish are taking. (Plate XI.)

"When fish are passing," writes Mr. Howard Fox (in *Land and Water*, Oct. 1868), "immense excitement prevails in the fishing towns, and the inhabitants rush about shouting, 'Hev'ah, hev'ah, hev'ah,' a magic sound for all Cornishmen. At St. Ives, in addition to the main seine, one or more stop-nets are simultaneously shot at right angles to it, thus more speedily and effectually cutting off all means of escape for the fish that have been partially surrounded by the seine. From one seine, 5500 hogsheads have been enclosed, landed and cured at St. Ives, equal to about fifteen million fish; but 1000 hogsheads is a fine catch, and much above an average on the south coast. Several years ago a seine at St. Ives was considered to have enclosed 8500 hogsheads, equal to about twenty-one to twenty-five million fish, when this immense body split the net, and only about 800 hogsheads were saved. The seiners have various difficulties to encounter when trying to enclose a shoal of pilchards, and it is more common to miss than to have a successful 'shoot.' The tide has to be carefully considered, for it runs with great force off all the headlands, and often carries a seine on a rock and splits it. After a shoal is fairly enclosed and the seine moored, there are still many dangers and perils; for instance, the Rashleigh seine at Port Gavern, near Tintagel, enclosed a fine shoal, but next day a ground sea came on which lifted the foot-ropes and enabled the fish to escape. Four days later the same seine again enclosed a fine lot of fish, and while the men were on shore they discovered, to their dismay, the head of a seal in their seine, which gentleman had broken through the net, and after feasting, broken out again, thus opening two magnificent means of exit for the fish, so that only thirty hogsheads were saved instead of

500 or 600 hogsheads. . . . Drift-boats can set their nets anywhere and have so many and such long nets that if these were joined together end to end they would extend 400 miles in length, and make as it were a wall or fence round the entire coast. Seines, on the contrary, can only be shot on certain stations or stems when the water is shallow and the ground smooth."

The drift-net fishery affords the larger proportion of the pilchards which are annually consumed in Cornwall, but the seine catches most fish. Pilchard fishing is very uncertain. Very few were caught on the night I was in Mevagissey. On one occasion ten boats with drift-nets went out in Torbay, opposite Paignton ; no distance separated the boats ; eight took nothing, one got about 100, and one boat several thousand—in such compact bodies do they swim. Large bodies of pilchards may be attracted to the vicinity of the boats by throwing into the water a quantity of cod's roe, imported from Norway for this purpose. The French fishermen adopt this plan in their sardine fishing.

*Quality of flesh.*—Excessively oily and very inferior in flavour to the herring. Large numbers are salted and consumed during the winter in Cornwall and Devonshire. Many are also sold and eaten fresh. When a pilchard is out of condition it is insipid and poor ; when in good condition its abundance of oil forbids it being much prized as food in a fresh state. Pilchards were not much used as food in England except in Cornwall and Devon ; but they are now sometimes to be seen in some of our Midland markets. If they are to be eaten fresh they should be cooked as soon as possible after they are taken out of the water, for the flesh soon deteriorates in quality. They may be fried as herrings. The approved method of cooking them, according to Mr. Howard Fox, "is to split and pepper, place one h flat on another, backs outside, and roast on a gridiron."

This is the process provincially termed "scrowling." An admirable way of curing them is that of "marinating," and we are convinced this fish when so prepared has only to be known to be thoroughly appreciated as an indispensable accompaniment of the breakfast table. Messrs. Gilson and Company, Bond Street, have some "marinated" pilchards as samples for the curious. The marinating process is, I believe, to soak the fish in strong salt water (Latin *marinus*, "belonging to the sea"), and afterwards to place them in vinegar or oil. When I was in Cornwall I was told that most people prefer them thus marinated.

*Commercial value.*—It is not possible to give even an approximate notion of the annual average value derived from the pilchard fisheries, because there are no published records of the amount of fish which are consumed at home every year, an amount which is very large indeed; but with regard to the salted pilchards which are exported to the chief Italian markets, records have been for many years published every year. The following statement of the total number of pilchards exported with price per hogshead is from Messrs. G. C. Fox and Company's Pilchard Circular for 1882; it gives a summary since 1870 to 1882.

| Year. | Hogsheads Total. | Price per hogshead to Curers. |
|---|---|---|
| 1870 | 6,048½ | 60*s*. to 90*s*. |
| 1871 | 45,683½ | 20*s*. to 68*s*. 6*d*. |
| 1872 | 1,138½<br>18,406 | Previous season's fish.<br>38*s*. to 85*s*. |
| 1873 | 31,019 | 25*s*. to 51*s*. |
| 1874 | 819<br>7,543½ | Previous season's fish.<br>60*s*. to 89*s*. |
| 1875 | 7,337½ | 52*s*. to 95*s*. |
| 1876 | 9,903 | 52*s*. to 100*s*. |
| 1877 | 9,477 | 40*s*. to 80*s*. |
| 1878 | 10,309 | 30*s*. to 60*s*. |
| 1879 | 11,937¾ | 41*s*. to 68*s*. |
| 1880 | 11,843 | 55*s*. to 80*s*. |
| 1881 | 13,963 | 42*s*. to 75*s*. |

Referring back to Mr. Fox's circular since the year 1815, the next largest export to that of 1871 was in 1847, when 41,623 hogsheads were exported, and the minimum 700 hogsheads, in 1829. The chief Italian markets for the pilchards import are Genoa, Leghorn, Civita Vecchia, and Naples, and the Adriatic (Venice), of which Naples imports the greatest numbers.

A short account of converting pilchards into *fumados* or *fermade* is here given from Mr. Howard Fox's contributions to *Land and Water*. "Women arrange them; first putting a layer of salt, then a layer of pilchards, and so on till the 'bulk' is from 3 to 5 feet high: the outside row of fish is laid with the heads out and slightly turned up and the inner rows at right angles to them.

"French and Spanish salt, being a larger grain, is much preferred to English for this purpose. The fish remain in the bulk for 30 days, during which time brine and oil drain from them into pits specially arranged for the purpose. They are then taken out, sifted free from the dry salt, washed in a sieve, and placed in regular order in casks of 50 gallons, called hogsheads, the tails of the fish pointing to the centre, and the heads out.

"Pressure is next applied by means of levers to which weights are hung, and the casks are refilled and pressed three times during the space of nine days; the weight of the hogshead should then be 476 lbs., and the fish in each cask will vary from 2500 to 3000 according to size; all under 8 inches in length being usually excluded and packed separately in other casks to be sold as small fish, chiefly for home consumption. The entire cost of curing ranges from 15*s*. to 22*s*. per hogshead. Whilst the pressure being applied, the oil escapes from crevices left for purpose in the bottom of the barrels. From 2 to 4 gallons of oil are obtained from each hogshead of summer fish. Pilchard oil is sold in Bristol and is converted into cod oil by forcing steam through it, and other processes, the price being always governed by that of cod oil, and varying from £30 to £40 per ton. Pilchard oil is excellent for mixing paints." This process, thus well described by Mr. Howard Fox, I witnessed at Mevagissey last October, where I also saw the sardine manufactory, which I hope will ere long be able to cope successfully with the French system, and help to lower the price of their tinned boxes of sardines, which at present, having almost a monopoly, is excessively high and not within the reach of general consumers.

*Names.*—The origin of the word *pilchard* is obscure; the final *d* is excrescent. The old spelling of the name was *pilcher;* "fools are as like husbands as pilchers are to herrings" (Shakespeare, Twelfth Night, iii. 1); probably of Celtic origin; compare the Irish *pilseir*, "a pilchard." Satchell gives the following provincial names, *gipsey-herring, herring-bairn, kiddle-winks, pilchard* and *sprat.* The Mediterranean *sardine*, which is only a variety of the pilchard, derives its name from the Greek σάρδα, or σαρδίνη (ī) which is described by Pliny as an elongated *pelamys* or "tunny;" the fish meant is uncertain; it was preserved as a salt relish, and had its name from the island of Sardinia.

"It was a salt luxury in high repute long before men had found out the art of saturating it with fine oil, and preserving it in a bath of the same, hermetically sealed in boxes. It is mentioned by Epicharmus' muse as among the friandise served at Hebe's wedding breakfast, and as Galen has pronounced 'Sardica salsamenta,' to be the pleasantest of relishes, and Apicius has entered it in his famous book of recipes as a fit subject for *farcie*, it was doubtless in one of those forms a favourite *mets* at most opsophagists' tables." The "sardica salsamenta" of Galen reminds one of the marinated pilchards of the modern inhabitants of Cornwall.

*General description.*—The pilchard is at a glance distinguishable from the herring by the radiating striæ on the gill-cover.

The following description is given by Günther :—

"The height of the body is nearly equal to the length of the head, which is one-fourth of the total (without caudal). Lower jaw but slightly prominent ; the maxillary extending somewhat beyond the vertical from the front margin of the eye. No teeth on the palate or on the tongue. Gill-rakers very fine and long, closely set. Ventral fins inserted below or nearly below the middle of the base of the dorsal. Origin of the dorsal fin considerably nearer to the end of the snout than to the root of the caudal. There are from 12 to 14 abdominal scutes behind the base of the ventral fins. Operculum with very conspicuous radiating striæ descending towards the suboperculum. A small blackish spot in the scapulary region."

### Var. *a.—Sardina.*

Base of the ventral fin below the middle of the base of the dorsal ; gill-rakers a little shorter than the eye.

### Var. *b.—Pilchardus.*

Base of the ventral fin behind the middle of the base of the dorsal ; gill-rakers a little longer than the eye.

There is a species or probably only a climatal variety of the pilchard, which occurs on the Pacific coasts of America, Japan, and New Zealand, viz. the *Clupea sagax* (see Günther's Catalogue, vii. p. 443).

## THE CONGER-EEL.

### Family *Murænidæ.*

"Body elongated, cylindrical or band-shaped, naked or with rudimentary scales; vent situated at a great distance from the head; ventral fin none; vertical fins, if present, confluent, or separated by the projecting tip of the tail; sides of the upper jaw formed by the tooth-bearing maxillaries, the fore part by the intermaxillary, which is more or less coalescent with the vomer and ethmoid. Humeral arch not attached to the skull. Stomach with a blind sac; no pyloric appendages. Organs of reproduction without efficient ducts." (Günther.)

The Murænidæ are widely distributed, and are found in the seas and fresh waters of the temperate and tropical regions.

GENUS *Conger.*—"Scaleless; cleft of the mouth wide, extending at least to below the middle of the eye. Maxillary and mandibulary teeth arranged in series, one of which contains teeth of equal size, and so closely set as to form a cutting edge; no canine teeth; vomerine band of teeth short; pectoral and vertical fins well developed, the dorsal commencing behind the root of the pectoral; gill-opening large, approximate to the abdomen; the posterior nostril opposite to the upper or middle part of the orbit, the anterior in a tube; eyes well developed; seas of the temperate and tropical regions.

"The skeleton of *Conger* is distinguished from that of *Anguilla* by the greater development of the transverse processes of the vertebræ, especially of the caudal.

"The caudal vertebræ of *Anguilla* have no transverse processes." (Günther.)

Γόγγρος.—Aristot. i. 5, § 2; ii. 9, §§ 4, 5; ii. 11, § 8; vi. 16, § 6; viii. 4, § 2, &c. Oppian, Halieut. i. 113, 521.

*Conger.*—Pliny, ix. 24, 37; Plautus, *Mil.* 3, i. 162; *Pers.* i. 3, 30.

*Congre.*—Belon, de Aquat, p. 162; Rondel. i. p. 308.

*Muræna.*—Artedi, Spec. Pisc. p. 40, No. 3; Gen. p. 240.

*Muræna conger.*—Lin. Syst. Nat. i. p. 426; Lacép. ii. p. 268; Donovan, Brit. Fish. v. pl. 119; Nilss. Skand. Faun. iv. p. 680.

*Anguilla conger.*—Flem. Brit. Anim. p. 200; Jenyns' Man. p. 478.

*Conger vulgaris.*—Cuv. R. Anim.; Yarrell, ii. p. 402; Thompson, Nat. H. Irel. iv. p. 227; Günther's Catal. viii. p. 38.

*The Conger, or Conger-eel.*—Willughby, p. 111, tab. G, 6; Pennant, Brit. Zool. iii. p. 196; Couch, iv. p. 340, pl. 238.

*Leptocephalus morrissii auctorum* is the abnormal larval condition of the conger.

*Geographical distribution.*—The conger has a very wide geographical distribution, being found off the coasts of Europe, in the Mediterranean, South America, East India Archipelago, Japan and Tasmania. It occurs on all the rocky parts of the British shores, and is very abundant on the coast of Cornwall and Devonshire.

*General habits.*—Congers prefer deep water, and are fond of retiring to holes or crevices in the wells; this rock-loving habit may be observed in specimens kept in the large tanks of our aquaria. They are susceptible to cold and to changes in the temperature. Some prefer to keep rather to sandy shores, and to bury themselves in the mud or sand, from whence people acquainted with their habits dig them out on the retreat of the tide. They are not generally great wanderers. They feed principally in the night, and are excessively voracious, not sparing their own kind, a fact mentioned by Aristotle. A conger, moreover, when captured, often exhibits great ferocity; "flying at you like a bull-dog," is a fisherman's expression. Thompson (Nat. Hist. of Ireland, iv. p. 228) relates how a gentleman once cut the head off a conger, and holding the severed member in his hand, his servant set about taking the hook out of his mouth, when the teeth closed on his thumb, as if in life, and bit him desperately. It was only by cutting the jaw to pieces that the thumb was liberated. Again, Mr. R. Paterson was witness to the following occurrence. "Two fishermen had brought the produce of their long-line fishing to shore; among their captures was a large conger-eel, off which they chopped the head, left it lying on the beach, and departed; a little bare-footed boy strolling along soon afterwards began "poking" his toes into the mouth of the eel. To his amazement the jaws closed on his foot, and held him fast until his cries brought the neighbours to his assistance."* The conger uses its powerful tail with great effect. "When taken on board," says Couch, "and left undisturbed, the sensitive powers of its tail are employed in searching out the nature and limits of its prison; and then this organ is stretched out to lay hold of the gunwale; by fixing its holdfast on which, a reversed muscular contraction is put in force, and the whole body is turned overboard; to prevent which, however, when the fish is first taken, it is usual to inflict a smart blow with the *bat* or bludgeon on the root of the tail, or on the vent, either of which is effectual in disabling the victim. But again, if the hungry fish has had the mishap to have found its way into a crab-pot, the method of escape is with some amount of difference, although the tail is still the instrument employed. Thrust between the upright willow rods, they are thus pressed asunder to allow of the reversed muscular action of the body, and at last of the passage and escape of the head. A further and somewhat different proceeding is the resource when the fisherman's hook is fastened in the jaws, and a revolving action is particularly successful when the line is of the sort termed a bultey or longline; especially when also the fish is at an early stage of growth: for fishermen report that this method of deliverance is less frequently employed by the older fish. As soon as the restraint is felt, the revolving motion begins, by which the shorter line is twisted into a ball, with a force that is often sufficiently strong to wrench the hook from the jaws." This revolving motion is not peculiar to the conger, for the common eel of our rivers and ponds is given to the same device.

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* Couch mentions the two following anecdotes, which appear to savour of "the marvellous." "A fisherman had safely taken a stout conger into his boat, when the fish snapped at and caught his foot within his mouth, and sprang overboard, carrying his shoe with it. In another instance, where the fish was of a large size, the result was rather amusing than formidable, but the lesson to be taught is that there is danger in incautiously meddling with these fish. A man had thrust his foot into the mouth of a conger that showed little signs of life, when suddenly the jaws grasped it, and an active revolving motion began by which he was dashed to the ground with considerable violence."

*Food of.*—Lobsters, crabs, and other crustacea, small fishes, molluscs; said to devour largely herring spawn; though at times voracious, the conger's appetite is variable, and in the opinion of the fishermen it exercises delicate choice in what it devours. "If a whelk was to get on the bait," said Robinson Crusoe to Mr. F. Buckland, "the conger would never touch it, not if you was to bide all night; there's not a delicater fish as swims." Congers, unless sorely pressed by hunger, will not take tainted bait; they devour soles and plaice, &c.; skulpins and even the well-armed weaver fish are often found in their stomachs. Couch relates that he has taken a lobster of the largest magnitude from the stomach of the conger, and that one of fifty pounds' weight was found to have once seized a hake weighing four pounds, which it had laid hold of high in the water, and that the conger will sometimes mount to a depth of seven or eight fathoms over the sounding of fifty fathoms. Mr. Templeton in a note published by Thompson states that a vessel was once wrecked on the coast of Rathlin, laden with salt herrings, and that the congers ate voraciously of the salt fish, and great numbers died and were washed on shore, after this unlucky feast, for several days.

*Spawning.*—Every one who has paid any attention to the spawning of eels is well aware how the whole question is still beset with difficulties and uncertainty; and although this is true more completely and decidedly in the case of our fresh-water eels (*Anguilla*), yet even in the case of the marine conger much remains to be explained.

Speaking of the common fresh-water catadromous eel, Dr. Jacoby well observes—"Among all the animals that surround us the eel is the only one which has never unveiled the secret of its propagation, even to the most persevering investigators. This assertion, made almost forty years ago by Martens in his work 'Italien,' is true to some extent even at the present day. To a person not acquainted with the circumstances of the case it must seem astonishing—and it certainly is somewhat humiliating to men of science—that a fish which is commoner in many parts of the world than any other fish, the herring perhaps excepted, which is daily seen in the market and on the table, has been able, in spite of the powerful aid of modern science, to shroud the manner of its propagation, its birth and its death in darkness, which even to the present day has not been completely dispelled. There has been an eel question ever since the existence of natural science." (The Eel Question, U. S. Report, p. 463.) One great puzzle was that for ages no male eel had ever been seen. Patient investigators, from time to time, described what they considered to be the male sexual organs, but then some other investigator arose, and proved that what others had taken for undoubted evidence of the male organs turned out to be something else. Of course the actual detection of moving spermatozoids in an organ would settle the matter at once; but the exceeding minuteness and active movements of these bodies render satisfactory conclusions difficult of attainment; it is easy to mistake the trembling motions of minute particles—"Brown's molecular movement," for instance—for true spermatozoa. If the characteristic caudal vibrating filament of each spermatozoon reveals itself, then there can be no doubt of the nature of the moving particle; but those who have examined the milt of various fishes know that it is difficult, even under very high microscopic powers, to satisfy the eye in many instances of the existence of the caudal filament. Although, as a rule, a spermatozoon is a minute round or oval body with a moving tail, some spermatozoa seem to be merely globular in form, and to be destitute of a filament. At last, however, it seems that male eels and congers have been discovered. Dr. Syrski, formerly director of the Museum of Natural History at Trieste, now Professor in the University of Lemberg, took up once again the eel question. In a certain number of eels (November 1873) examined by Dr. Syrski he discovered a new organ which had never before been seen within the eel by any former investigator, although tens of thousands of eels had been zealously studied. "Syrski published his discovery in the April number of the Proceedings of the Imperial Academy of Sciences, Vienna, in 1874. The most important point of the discovery was stated to be that in all the specimens of eels in which the Syrskian organ was found, the well-known collar and cuff-shaped ovary, the female organ of generation, was entirely wanting. It was evident from this that eels were not hermaphrodites. The question now arose, Is the newly-discovered organ in the eel, in its external form as well as inner structure, so different from the ovary that it cannot possibly be considered as a partially developed or shrunken state of that organ? According to all researches which have up to this time been made, there is the highest kind of probability that this newly-discovered structure is actually the long-sought male organ of generation. Still, at that time, so far as Syrski investigated, though there was great probability in his opinion, it yet lacked positive proof by the detection of the spermatozoids in the Syrskian male organ. The conger eel has lately afforded what may be considered a confirmation of Syrski's views. Dr. Otto Hermes discovered spermatozoa in the spermaries of the conger eel in June 1879. This most interesting and important discovery, with Syrski's work, marks quite an epoch in the natural history of the eel. "Since the beginning of last spring, when the eel fisheries in our part of the country commenced, I have given my undivided attention," writes Dr. Hermes, "to the eel question, to dispel, if possible, the darkness which still hides the life of this mysterious fish. I do not hesitate to communicate, at the present time, the results of my investigations to the readers of the Circular, with the hope of stimulating others to make observations of this problem. It was natural to extend these investigations to the formation and development of the sexual organs of the sea eel (*Conger vulgaris*), which so closely resembles the fresh-water eel, all the more as its sexual organs and the manner in which it reproduces its species are likewise but little known. If positive facts could be ascertained with regard to this eel, it would be tolerably safe to conclude, from the similarity of the two kinds of fish, that the same would apply to our common river eel (*Anguilla fluviatilis*).

"The sea eel grows twice as long as our river eel (specimens measuring 6 feet in length are by no means uncommon), and outwardly differs from the latter by the different formation of the jaws and the dorsal fin. In the sea eel the latter begins immediately back of the pectoral fins, whilst in the river eel it is placed farther back. In the sea eel the upper jaw protrudes over the lower jaw, in the river eel the reverse is the case. The position and formation of the internal, especially the sexual organs, are very similar in both. But whilst the river eel grows up in rivers and only goes into the sea to spawn, the sea eel never leaves the sea. The sea eel stands imprisonment very well and grows rapidly. I have had a considerable number in the Berlin Aquarium, and have examined several large ones which died. These were invariably female fish whose ovaria had developed to an extraordinary degree. From lack of the natural conditions they could probably not spawn, and I believe that they died from this cause.* I have been informed that a sea eel in the Aquarium in Frankfort-on-the-Main actually burst in consequence of the unnatural development of the ovaria.

"In the autumn of 1879 I received a number of sea eels which had been caught near Havre, measuring 60 to 70 centimeters in length. They ate voraciously and grew rapidly. Only one did not develop so fast, and could easily be distinguished from the others by its smaller size. This, the smallest of all the sea eels in the aquarium, died on June, 29th 1879, and was examined by me the same day. I was very much surprised when I discovered that its sexual organs were entirely different from those hitherto observed in eels. When an incision was made in these organs a milky fluid oozed out. I had before me a mature male eel. A drop of this fluid, when placed under the microscope and magnified 450 times, showed a large number of spermatozoids, whose head and tail could easily be distinguished. They moved about in a very lively manner, thus fully establishing the fact that the organs examined by me were male organs. As to my knowledge no mature male of the *Conger vulgaris* had ever been found or described, I requested Dr. Rabl-Rückhard to examine this fish with me, and had correct drawings of the organs made by a painter." ('The Propagation of the Eel,' by Dr. Otto Hermes, Circular No. 6, Berlin, November 25th, 1880, of the "Deutsche Fischerei-Verein"—German Fishing Association.)

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* This is probably not a very uncommon occurrence. Mr. Long, of the Southport Aquarium, tells me that last year a conger 20 lbs. in weight died in spawn, in that aquarium.

It seems pretty clearly proved that the male of both the sea eel and the river eel is considerably smaller than the female; but no more need be said here than that the researches of Syrski and Hermes and Jacobi have paved the way to the complete solution of the various problems that have for ages puzzled the brains of investigators.

The conger is said by Yarrell to spawn in December or January; he states that the distinction of the sexes is obvious on the examination of the roe during the cold months. Couch says, "Although the grains may be shed through the summer, we only feel confident of them in the autumn." Perhaps there may be some difference as to the time of spawning. All that can be said is that further observation as to the time and mode of deposition of the spawn is necessary before we shall be in a position to make any affirmative proposition on this point. The remark of Mr. R. Q. Couch, that he had seen cases where the ova were as large as small peas, is opposed to what is known of the size of the ova in these fish. The growth of the conger is probably not fast, but this, as in the case of other fishes, depends on the food it assimilates. It seems to do well in the large tanks of our aquaria and to grow there if supplied with suitable food. As congers grow to an enormous size, 6, 8, or even 10 feet in length and thick in proportion, and as they spend much of their life in a comparative state of rest, with little demand on the expenditure of muscular vital force when food is abundant and accessible, congers probably, like our freshwater pike, may live to a great age, unlike, in this respect, to the river eel which appears to be short lived, often, if not always, dying after the spawning process. But here, again, extended and careful observations are necessary. Before leaving this part of the subject a few words must be said with respect to those curious abnormal, undeveloped, ribbon-like fishes known as *Leptocephali*. Dr. Günther thus characterises them: "The *Leptocephali* proper are small, narrow, elongate, more or less band-shaped fishes, pellucid in a fresh state, but assuming a white colour when preserved in spirits, resembling a tape-worm, being quite as soft and flexible. The skeleton is entirely cartilaginous, or slight ossifications are only now and then visible, especially towards the end of the vertebral column. The latter is replaced by a chorda dorsalis which in many specimens is found to be [illegible]ded into numerous segments. Neural arches are sometimes present in their rudimentary condition. The anterior end of the chorda dorsalis passes into the cartilaginous base of the skull, the connection not being by means of joint and ligaments. Hæmal arches are found on the caudal portion. Ribs none. The skull, like the vertebral column, is nearly entirely cartilaginous." ('Introduction to the Study of Fishes,' p. 179.) After specifying certain other characters, and stating that these fishes are found floating in the sea, frequently at a great distance from the land, that their movements are slow and languid, Dr. Günther remarks, "Taking into account all the various facts mentioned, we must come to the conclusion that the Leptocephalids are the offspring of various kinds of marine fishes, representing, not a normal stage of development (larvæ), but an arrest of development at a very early period of their life; they continue to grow to a certain size without corresponding development of their internal organs, and perish without having attained the characters of the perfect animal. The cause by which this abnormal condition is brought about is not known; but it is quite within the limits of probability that fishes usually spawning in the vicinity of land sometimes spawn in the open ocean, or that floating spawn is carried by currents to a great distance from land; and that such embryos, which for their normal growth require the conditions afforded by the vicinity of the shore, if hatched in mid-ocean, grow into undeveloped hydropic creatures, such as the *Leptocephales* seem to be." The largest specimen of *Leptocephalus* observed by Günther was 10 inches, but specimens of that size he states to be rare.

According to the opinion of Mr. Gill, the typical *Leptocephali* are the young abnormal larval forms of the congers; and *L. morrisii.* "The Anglesey morris" of

Pennant, Yarrell and other authors is the young of *Conger vulgaris;* with the correctness of Mr. Gill's views Dr. Günther expresses himself fully satisfied. If these creatures are individuals arrested in their development at a very early period of their life, it is quite probable that some specimens would be in some respects more developed than others, such a phenomenon being quite consistent with analogous cases in other classes of animals, and their variety of form is as a matter of fact actually found, and, as Dr. Günther remarks, this extraordinary variability favours the supposition that they are individuals abnormally arrested in their development. The Leptocephalic form of the *Conger vulgaris* is thus described: "body compressed, its depth being about equal to the length of the head. Sometimes the body, sometimes the tail, the longer. End of the tail generally rounded, not prolonged. Snout obtusely rounded. Eye rather large. Tongue distinct. Pectoral fins developed. Jaws with or without small teeth. Chorda dorsalis without ossifications." Specimens of *Leptocephalus morrisii* are occasionally taken at different parts of our coasts. It is right to state that some authors, as Bleeker and Peters, do not consider Leptocephales as arrested forms of other fishes; the evidence, however, is strongly in favour of an abnormal larval state.

*Modes of capture.*—By hand-lines and bulters or long lines, the baits used being the sand-launce, squid, pilchard or herring. The pilchard is most esteemed by some fishermen, as in Cornwall and Devon; the French fishermen prefer the sand-launce. In Colonel Montague's time, French fishing boats used to run over from the coast about Dieppe to Slapton Bay on the south of Devon, on purpose to purchase launce. In Guernsey, long famous for its congers

—the rocky character of the coast being well suited to the habits of the fish—squid is considered to be the best bait. Mr. Low tells us that in the Orkney Islands the piscivorous otter is utilised by the people as a means of supplying them with congers. Some are caught on the fishermen's lines, but the otter is by far the most successful in killing congers. He brings them ashore, and eats but a very small part, leaving the rest for the next comer; and where his haunts are known, the country people are very careful every morning to search for the remains of his overnight's feast, and are seldom disappointed, usually finding cod ling sometimes, but especially congers, which are oftener seen amongst the deep hollows of the rock than further at sea. The partiality of the otter for eating a small part only of the fish it captures I have myself witnessed. I know a case where a whole barrowfull of carp was in a single night brought to land from a small stew in Shropshire; only the noses of the carp had been consumed, that organ evidently having been considered the otter's *tit-bit.*

Congers do not generally take a bait during the daytime, and moonlight nights are not the most favourable for fishing; they are caught at all distances from the shore, and nearly always from rough or rocky ground. A large number are taken off the Cornwall and Devon coasts; and the Brixham line boats supply the market there during the autumn and summer months.

*Quality of flesh.*—Coarse and of unpleasant flavour, especially the large fish; but a small conger of about 2 feet long is not bad when fried, especially when you are hungry. I am aware that the opinion expressed above may by some people be regarded as the offspring of an unreasonable prejudice; for I have known people who are very fond of conger, and who regard it as "one of the best fish that swims." That it is wholesome and nutritive there can be no doubt, and that it affords large supplies of fish food at a cheap rate to the poorer classes is certain. Much value is said to be set on the fatty fringes which contain the eggs, which, from the absence of all disagreeable smell and taste, is employed in select cooking. Judicious cooking of the conger doubtless improves its natural qualities to a very great extent. In Guernsey conger is the important ingredient in the white soup of that island. I confess I did not care for it when I visited the island some years ago. It may be cooked in various ways, baked, boiled (worst method of all), fried, made into a pie, or into soup, &c. A conger pie is a favourite dish in Cornwall; almost everything in Cornwall is made into a pie, it is said, and this is the reason why the devil is never seen in Cornwall, because he is afraid of being made into a pie!

In mediæval times *conger* or *congur* figures with samoun (*salmon*), bret, turbut, &c., and was a chief fish at the tables of the great. (See John Russell's 'Boke of Nurture in Early English Meals and Manners,' Edition Furnivall, 1868——.) Muffett says :—" I must needs agree with Diocles, who being asked, *whether were the better fish, a pike or a conger:* 'That,' said he, 'sodden, and this broiled, shewing us thereby that all flaggy, slimy, and moist fish, as eeles, congers, lampreys, oisters, cockles, mustles and scallopes, are best broiled, rosted, or bakt; but all other fish of a firm substance and drier constitution is rather to be soden'" ('Early Meals and Manners,' p. 38, note).

Formerly the flesh of the conger was prepared by drying in some particular way, it was then ground into a powder, and exported to Spain and other countries. In this grated state it was used to thicken soup. Would it not be desirable to introduce some similar preparation of conger nowadays? All that is wanted is that culinary art should improve the conger's natural flavour; nutritious properties the fish possesses already.

*Commercial value.*—At Grimsby the ordinary wholesale price of conger is from 2*s.* to 4*s.*, 5*s.* or 7*s.* 6*d.* each; the prices are not generally quoted in the London market. Large quantities are, however, sold by the London street-sellers, and conger is much used in making eel soup for the poorer classes. Our large towns, as Liverpool, Manchester, Sheffield, Birmingham, &c., supply in their markets quantities of conger, which is usually sold retail at about 3*d.* per lb. I have no means of ascertaining the quantity annually sold and consumed, but it must be very considerable.

*Names.*—The English name of conger is derived from the Greek γόγγρος, "a conger," which also denotes an excrescence on trees. The Greeks were excessively fond of conger. "Greek hyperbole," says Badham, "seems to have reached its climax in describing the delights of a conger feast. One unsavoury Achæan declared that the fragrant odour exhaled from its body in cooking was sufficient to restore the lost sense of smell to a dead man's nose, and that boiled in fine brine it was a dish to change the human nature into the divine. To quote but one more specimen of gastronomic rodomontade, a bombastic enthusiast, hearing from his caterer (amidst the names of fish in the market read out for his money consideration), those of leucisci and conger, stops him to say, that in place of naming fish he was rehearsing a list of gods" (Prose, Halieutics, p. 392). Satchell gives the following provincial names of the conger: *evil-eel*, *heavel*, *heawe-eel*, *milwel*, and *white-eel*.

*General description.*—"The dorsal fin begins opposite or nearly opposite to the extremity of the pectoral. Posterior nostril on a level with the antero-superior angle of the orbit. Jaws nearly equal in front. The vomerine teeth reach backwards nearly to the tips of the tongue. Body and pectoral fin immaculate." (Günther.)

### FAMILY *Rajidæ.*

"Disk broad, rhombic, generally with asperities or spines; tail with a longitudinal fold on each side. The pectorals extend to the snout. No electric organ, no serrated caudal spine. Chiefly inhabitants of the temperate seas of both hemispheres, and much more numerous in the northern than in the southern seas."

GENUS *Raja.*—"Two dorsal fins on the tail, without spine; tail, with a rudimentary caudal fin, or without caudal. Each ventral fin divided into two by a deep notch. Teeth small, obtuse or pointed. Pectoral fins not extending forwards to the extremity of the snout. Nasal valves separated in the middle, where they are without a free margin." (Günther.)

### The Common Skate (*Raja batis*).

*Raja.*—Artedi, Gen. p. 73, No. 9; Spec. Pisc. p. 102, No. 9.

*Raja batis.*—Lin. Syst. Nat. i. p. 395; Flem. Brit. Anim. p. 171; Jenyns' Man. p. 510; Nilss. Skand. Faun. Fisk. p. 738; Yarrell, ii. p. 561; Günther, Catal. viii. p. 463.

*Skate Ray.*—Pennant, Brit. Zool. iii. p. 111, pl. xi.

*Raja intermedia.*—Parnell, Proc. R. Soc. Edin. 1837, p. 166; Yarrell, ii. p. 558.

*Skate.*—Couch, i. p. 87, pl. 18.

*Geographical distribution.*—Coasts of Europe, more or less common on the western coasts of Norway and Sweden. Common off the west coast of Jutland, and in the Bohus Skärgärd; a doubtful inhabitant of the Baltic; frequent in the Orkneys, in the Forth and the coast of Scotland. In Ireland it is taken round the coast, but less commonly in the north at least than *R. maculata* and *R. clavata.* Thompson says that the rays are less known in Ireland than most other fishes, in consequence of their being rarely brought to market, and when exposed for sale they are usually in an imperfect state.

*General habits.*—Resides on the ground for the most part like the rest of the family, and prefers a soft and sandy bottom. Is a voracious fish ; when hooked it will be quite still, and for some time the fisherman hardly knows whether he has hooked a skate or is foul at the bottom. Possessed of large expanded pectoral fins, which present a wide surface to the water, and having great strength, it requires some skill in the fisherman to bring it safe into the boat. If a skate is hooked, the only resource is patience, for the fish if pulled at will, remains immovable as a rock. When the skate voluntarily stirs, the fisherman tries to get his head well up in the water and to keep it in that position till it is raised to the surface. Thompson quotes from the *Cork Reporter* (1849) an account of a large skate which weighed 2 cwt., and was caught in the following manner: "A small skate got meshed, and was swallowed, with a piece of the trammel of the net, by the large one, and being thus entangled in the netting, it was easily secured by the fishermen." It is interesting to note the skate's mode of progression in the water; the pectoral fins are gracefully moved in an undulating fashion, as Yarrell says something between flying and swimming, a movement expressed by north country fishermen as "shuddering." The movements of young skate 5 or 6 inches in length (without tail) in an aquarium is, I always think, a very attractive sight. Skate are able to sustain severe injuries and are generally tenacious of life. They use their tails which they lash vigorously with considerable effect.

*Food of.*—Other fish, especially ground fish, as Pleuronectids, or fish of not very active habits. Crustacea, as crabs, lobsters, &c. Couch found in one a fishing frog (*Lophius piscatorius*) that weighed upwards of six pounds, in another two large plaice, two mackerel, a thornback-ray and half a salmon. It does not seem likely that the skate should be at all particular in its diet; growing as they do to enormous sizes, the food they require must be considerable. Fishermen, however, say that it is rather choice in the selection of its food, and that it prefers herrings or pilchards as a bait.

*Spawning.*—The young are produced during the spring and summer. Like those of the oviparous chondropterygians, they are hatched from ova invested with tough, horny or leathery envelopes of various form, according to the different genera. The large horny cases of the skate family must be familiar to sea-side visitors; there are nearly always the empty leathery cases from which the young have been excluded. These horny cases are sometimes called by the name of skate-barrows, from the resemblance in shape to those oblong four-handed wooden vessels in which butchers and others carry their goods. The four corners are in the dog-fishes produced into extremely long flexible filaments which attach themselves to floating or submerged bodies in the water, and seem to moor the young contained embryoes within it, firm as an anchor, to withstand the movement of the water, either of the waves or of currents. The ovum of the skate has merely short prolongations. The impregnation takes place before the ovum is invested with its horny covering, and therefore actual copulation is necessary in these fishes; a fact well known to fishermen, who frequently in the early summer months catch both males and females closely united by the so-called "claspers" of the former, which both mechanically and functionally are intromittent organs. In the rays the sexes differ in the development of dermal spines and in the form of the teeth; the females are generally much rougher than the males, and larger.

The growth of these fishes is probably not rapid; they slowly and steadily increase in size, and are probably long lived. The horny ova are shed in pairs, according to Couch, at apparently short intervals, and are not generally attached to any object. The time which the embryo requires to mature till ready for exclusion has not, I believe, been definitely observed. Skate attain an enormous size and weight, measuring 7 feet long and 5 broad, and weighing 2 cwt. It often requires the aid of two men to carry these huge heavy slippery monsters.

*Modes of capture.*—By the trawl; a few are caught by baited hook and line.

*Quality of flesh.*—As an article of food this fish is variously estimated, some preferring it to almost any other kind of fish, others again not caring for it at all. Among the fishermen skate is a favourite fish, and I have heard them say that there is nothing in the sea so good as a "bit of tawed (towed) skate." The usual edible portions are cut off, and in order to get rid of the quantity of slime or mucus which covers the skin, they are secured to a cord and thrown into the sea, and towed for some distance through the water. The flesh is nutritious, firm and wholesome when in season, but soft and valueless soon after spawning. In the London West End shops skate is usually exhibited in a crimped state, and certainly it has a very appetising appearance. I consider skate to be a very good fish, and think there are few dishes better than a piece of boiled skate served with cockle sauce. There is a good deal of cartilaginous substance in this and other fishes of the same family, and this is highly prized by some people and disliked by others.

*Commercial value.*—Enormous quantities of skate, but not of this species only, are annually consumed by the poorer classes of this country, and though not a high-priced fish compared with many other kinds, the skate has a very considerable commercial value. In the Grimsby market the usual wholesale price of skate is from about 3*s.* to 5*s.* 6*d.*, 8*s.* or 10*s.* each. Great quantities are taken by the North Sea trawlers, and skate has a ready sale. This fish, though other species are included under the term of 'skate,' is always distinguished from the thornback ray (*Raja clavata*) by the fishdealers at Grimsby; this latter fish is called *Roker*, which is evidently the Danish word *rokke*, the name of this fish in Scandinavia. The thornback is generally considered inferior as an article of diet, though some people esteem it. The usual price at Grimsby is from 5*s.* to 10*s.* per score. When all fish, however, is scarce, owing to bad weather, rokers will fetch as much as 20*s.* or 22*s.* per score. The roker is one of the few fish I have not tasted, and cannot report on the quality of its flesh. In dissecting specimens I could detect a peculiar pungent odour resembling ammonia, which after a time became so strong as to render my room quite unpleasant. I have been informed by the Liverpool fishmarket people that so strong is this odour on unpacking baskets of this fish that it produces unpleasant feelings and causes the eyes to water.* This odour is doubtless dissipated entirely by cooking. Great numbers of thornbacks are annually caught around our coasts, and are eaten both fresh and salted by many poor families. They are caught all the year round, but more abundantly in the spring and summer, when they come nearer inshore than during the winter months. All the *Rajidæ* are in best condition in the late autumn or winter months. The food of the thornback is similar to that of the skate, and, like it, it is said to be somewhat particular in its choice. Couch considered the thornback as the most valued of the rays. Fishermen distinguish between *rays* and *skates*, the latter being the name of the larger fish; they are not guided by any real distinction so far as I could make out. Couch proposed the name of *batis* as a genus for the skates, which he thinks are to be separated from the rays because a decided and permanent mark is to be found in the dusky colour of the skate's under surface, while that of the rays (*Raia*) is pure white. It is obvious that the distinction of colour cannot be relied upon even to discriminate a species, let alone a genus. All the British members of the *Rajidæ* are regarded by Günther as belonging to the single genus of *Raja*, of which two general divisions are given, viz. (*a*) short-snouted species and (*b*) long-snouted species. The division is only generally true, as intermediate snouted specimens occur. Beside the two fish mentioned, other species, all of which are probably edible, occur on our coasts, and I have occasionally seen specimens in the market or in the trawl-smacks; but it is not deemed necessary to give any detailed account of them. Young specimens of the rather rare and very prettily marked bordered ray (*R. marginata*) I have seen taken not unfrequently when trawling in Torbay.

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* I have observed the same peculiar odour in the electric organs of the *torpedo*.

*Names.*—Our word *skate*, or *scate* as spelt by old English authors, is the Icelandic and Norwegian *skata*, which is the

Latin *squatus*, "a kind of shark," a "skate." *Squatina* is mentioned by Pliny (ix. 12, 14); it appears to be the angel fish *Squatina lævis*, Cuv. (*Rhina squatina*). *Ray* is from the Latin word *raia*, used by Pliny for "a skate." Provincial names of the common skate are *blue skate*, *dinnen skate*, *grey skate*, *little maid*, *maid*, applied to small females, *piper* (?) *skider*, *wild mare*, *tinker*, *three-tailed skate*, applied to the male with its two long "claspers;" *tinker*, in allusion to the dark colour. The thornback is known by the names of *eeck*, *mavis*, *ray*, *ray-maid*, *rough-ray* and *thornback-maid*.

*General description of the Common Skate.*—Snout long produced, pointed; the *anterior profile* (from the snout to the angle of the pectoral fin) *is deeply emarginate*, *not or but slightly undulated*, *mouth transverse*, *nearly straight*. Teeth somewhat pointed, in about 52 or 56 series in the upper jaw; outer pectoral angle produced and rather pointed. Body rough in adult female examples, but nearly smooth or with patches of minute asperities, more numerous on the upper and lower sides of the snout than in any other region; males nearly smooth. *Body without larger spines*, except one in front and behind the eye in young examples; one or three series of large spines on the tail. Disc much broader than long. Upper surface of the body dark olive-green, uniform or with numerous large white spots; under surface dark grey, with minute specks of a deeper colour (Günther). The form of *intermedia*, regarded as a species by Parnell, is by Günther considered as a variety of *batis*; he thinks it not improbable that these *intermedia* forms may be hybrids between *R. batis* and some other long-snouted species.

# IMPROVED FACILITIES

FOR THE

# CAPTURE, ECONOMIC TRANSMISSION,

AND

# DISTRIBUTION OF SEA FISHES.

"*EX ABUNDANTIA.*"—[H. P. BLAKE.]

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# IMPROVED FACILITIES FOR THE CAPTURE, ECONOMIC TRANSMISSION, AND DISTRIBUTION OF SEA FISHES.

## INTRODUCTION.

BEFORE I commence this paper, it may be well to explain my reading of the particulars given for the guidance of competitors.

I understand that the Essay will be expected to deal principally with fishing operations on the British and Irish coasts, and with the distribution and transmission of fish, so far as it applies to Great Britain and Ireland. However, in passing I shall take occasion to make some mention of the fishing trade of other countries.

The enquiry should be directed, I understand, to the distribution of fresh sea fishes, leaving out of consideration all tinned, and salt, or otherwise cured fish.

I think shell-fish and fishing hardly come within the scope of this Essay, so have decided not to include any mention of same in my remarks.

With this explanation I will at once proceed to the consideration of the first part of the subject.

## ON IMPROVED NETS AND MODES OF CATCHING SALT-WATER FISH.

The principal kinds of nets used in salt-water fishing are :—

1st. The drift- or driving-net.
2nd. The beam trawl-net.
3rd. The seine-net.
4th. The kettle-net.

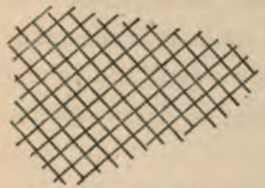
**Drift-net.** Little alteration or improvement has been made in the drift-net, it having from time immemorial been used in almost exactly its present form, and in the same manner, for fishing in shallow waters, and for surface-fishing in deep water.

On our coasts it is principally used for catching herrings, mackerel, and pilchards. It is advisable that the mesh of this net should be as large as possible, for besides the destruction of immature fish from the use of a small mesh, it must be borne in mind that a drift-net with a small mesh will not catch large fish, while with a large mesh the small fish escape, and only the larger ones are caught.

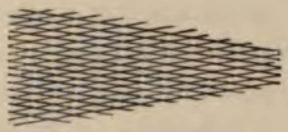
It will be easy, therefore, for the authorities to decide, if necessary, what shall be the size of mesh in the drift-net.

**Beam trawl-net.** The beam trawl-net is comparatively of recent introduction, as it seems to have been first used at Brixham and Barking in 1835. It was afterwards introduced at Ramsgate by Brixham fishermen, and later at Hull and Grimsby, until now it is in general use. The fish principally caught by this net are soles, turbot, plaice, haddock, and ling, these fish swimming near the bottom of the sea.

It would seem to be desirable for all concerned that the size of mesh of the trawl-net should be as large as possible. It now varies from 4 inches to 1¼ inches square, and fish must be very small to escape through a mesh of the latter size. Besides the destruction of small fish, a net with a small mesh has the disadvantage of collecting all sorts of rubbish from the bottom of the sea. At present, when the net is drawn to the surface, the "cod," or end, is found to be full of sand, shingle, &c., which at times has to be literally dug out, having collected in a hard mass. This would seem to arise from the mesh being too small, and the end of the net being too much funnel-shaped; another reason, when the net is being dragged along the bottom, the weight of fish, &c., being all in the extreme end, the mesh (of a diamond shape) is closed, the form of same being altered as shown in sketch (B). It would seem, therefore, that whatever the size of mesh this is the result when fishing.



ORIGINAL FORM (A).

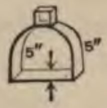


ALTERED FORM (B).

I have heard of the introduction of a square mesh, but consider that the tendency to elongate, and therefore close, would still be inevitable.

An invention that would secure the keeping of a given sized mesh to its original form and size, or nearly so, would be of the greatest value. The conclusion I therefore arrive at is, that until this result is secured, legislation is practically useless with reference to the size of the mesh of the beam trawl-net.

A trawl-net was exhibited at the Norwich Fisheries Exhibition, in which wheels were substituted for the ordinary irons at the end of the beam. One of the advantages claimed for this invention was ease in movement over the ground. I think, however, it is merely a fancied improvement. The shape of the irons at end of beam, as now generally used, is that of a flattened hoop, some 5 inches in width; and their action when in work would be similar, I believe, to that of a sledge on sand, slipping and sliding over the ground. But with wheels there would be a tendency to bury themselves in the sand at the bottom, in the same way that a cart-wheel does upon a sandy beach, and then when once buried to their centres it is probable they would refuse to revolve. Then sliding must follow, until the revolution of the wheels recommences, the same would be repeated again and again, and the mouth of net would at times be considerably closed and injured. I understand, however, that few, if any, of these nets have been used save by the inventor.



**Seine-nets.**

Seine-nets are worked from the shore with the aid of small boats, and generally in the finest summer weather.

This fishing is therefore objectionable, as it follows that the nets are used on the breeding grounds in the spawning season.

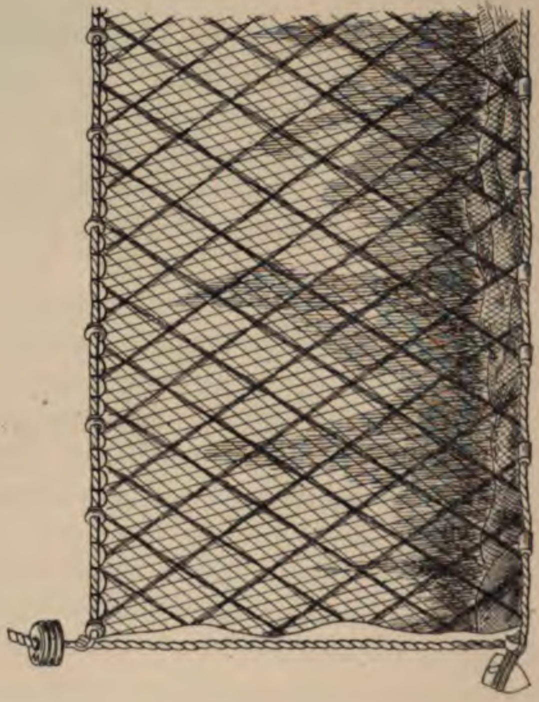
The mesh of the net is very small, and fish of all sizes and kinds are caught, principally the smallest.

I have seen quantities of whiting, mullet, &c., caught by the seine-net, the largest measuring about 7 inches in length.

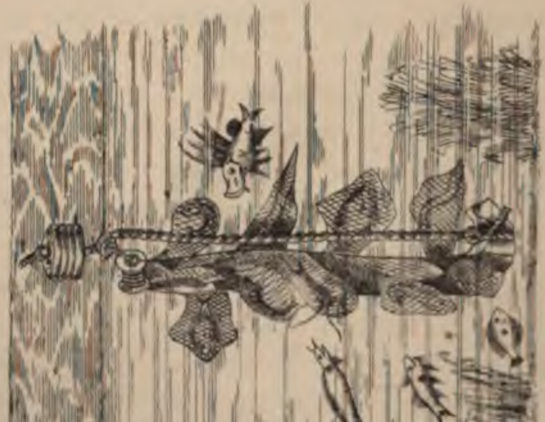
**Kettle-nets.**

The kettle-net is perhaps the most objectionable of all sea fishing-nets. They are worked on some parts of the coast where the shore is flat and sandy. The mode of operation is as follows: A large number of poles are placed upright in the sand to a great distance from the shore, those furthest off taking a circular form, and a net with small mesh is then stretched round these poles.

The fish seldom are snared in the straight part of net, mesh being so small. But generally they run into the



SIDE VIEW OF TRAMMEL-NET.



END VIEW OF TRAMMEL-NET.

trap or pound (formed by the way the net is set), and are taken from thence at low water. The special objections to its use are:—

All fish are caught, large and small; the larger ones are generally those that have come inshore to spawn, and sickly fish, but the greater number will be very small, as it will be understood this net is also set in the fish "nursery."

**Shrimp-nets.**

Shrimp-nets as generally used are somewhat similar in shape to a beam trawl-net, but the mesh is of course very small. The operation of "shrimping" is principally performed by small sailing boats, very close inshore. These boats, therefore, also fish in the "fish nursery," and with nets of the smallest mesh, and their use close inshore should be prohibited during the breeding season.

**Trammel-net.**

Trammel-nets. One of very good design is manufactured by Mr. J. S. Cragg, of Lowestoft. It is called by the maker a double-flued trammel-net, and its special feature is its usefulness on a rock-bound coast, where otherwise fishing by net could not be prosecuted.

The maker also recommends it for use anywhere as a capital draw-net (for catching any kind of fish), worked from small boats.

The inside loose net is about 18 feet deep, and the two outside nets about 8 feet deep. The mesh of the former can be of any suitable size, and of the latter about 12 inches square. The inside net is left loose, so that fish trying to get through "bag" themselves at the opposite side they strike at.

The accompanying illustration will fully explain the construction of this net. It is interesting to note that Mr. Cragg informs me that he manufactures four miles of drift-nets, 20 feet deep, per day, besides every other kind of net.

**Line fishing.**

Fishing by hook and line is a subject upon which I do not *propose to enlarge*, as I have not here any improved method to suggest. The principal question affecting its pursuit seems to be the supply of bait. The mussel, for instance, is perhaps the best kind of hook bait known, but the difficulty of procuring it in quantities appears to be rapidly increasing. This will point to the advisability of encouraging its culture, and possibly to a close season.

**Steam capstans.**

Perhaps the most marked improvement in the mode of fishing is that wrought by the use of steam capstans. I shall, however, notice this under a special heading.

**Conclusions.**

The general conclusions I arrive at upon "improved nets and modes of fishing," may be briefly stated as follows:—

**Nets.**

That, with perhaps the exception of the beam trawl-net, nothing new worthy of especial notice or commendation has been introduced for perhaps generations in the make of nets for sea-fishing.

**Size of mesh.**

That the attention of the authorities should be directed to the existing size of mesh of the various kinds of nets, with the view of seeing how far it may be possible to limit the minimum size of same, and to the possible improvement in the shape of nets and of mesh, especially in the trawl-net.

**Close season.**

That the use of the kettle-net should be entirely prohibited. A close season is positively called for, that is to say, fishing by trawl-nets of any kind should not be allowed within a certain distance, say 40 to 50 miles, of the shore during a given period of the year. And fishing by seine, shrimp, and all nets of similar kind, should be entirely prohibited during a close season. There exists a great difference of opinion as to all-the-year-round fishing by drift-nets, but my information leads me to think it unnecessary, at least at present, to interfere in any way with the season or locality of this fishing.

It must be remembered that these nets do not interfere with the spawning grounds, as do the other nets I have been speaking of.

In the early spring, late autumn, and winter months, trawl fishing may be prosecuted to within, say, 5 miles of the shore, and the least harm will then be done by fishing with seine and similar nets.

For the purpose of regulating the distance of trawl fishing from the shore, and the time of close season, it will be necessary that an agreement shall be made with at least the following powers: France, Belgium, and Holland.

**Limit of size of fish allowe to be sold.**

Perhaps it is within the lines of this section to note that it is useless to put a limit upon the size allowed to be sold of most sea fish, as the small fish would still be caught, but thrown overboard at sea dead or dying.

## THE APPLICATION OF STEAM TO DEEP-SEA FISHERIES.

**Steam fishing vessels.**

The question of the propulsion by steam power of vessels employed in deep-sea fishing is one deserving, I think, of minute and careful consideration. The "getting" of nets and gear by steam capstans may be taken from actual experience to be quite practicable and profitable, as they have been used for some years past with marked success by both English and foreign fishing vessels.

But the problem of the general use of steam-propelled fishing vessels is still in its earlier stages, and cannot be looked upon as definitely settled.

**History.**

The application of steam as a propelling power for fishing boats, as far as our coasts are concerned, is of recent introduction; and it will be seen from the title of various companies that have been started that they do not profess to be owners of vessels that are only employed in steam fishing. For example, we hear of the Hull Steam

Fishing and Ice Company, Limited; the Yarmouth Steam Trawling and Carrying Company; the Tyne Steam Towing and Fishing Boat Owners' Association, &c., all showing that other business than fishing is mixed up in their employment. And such is really the case.

The steam vessels of the last-named association are ordinary paddle tugs, used for fishing purposes when not engaged in towing. Their use as trawlers was first started in 1876, and now twenty-four in number are at times thus employed. That they are so employed with advantage is shown by the fact that in the first year of the innovation only 406 tons of fish were landed from vessels engaged in steam trawling from the Tyne, against 2,345 tons in 1881.

This system has spread to Scarborough, where twenty-two similar steamboats are now at times employed in trawling. The vessels of the second-named company are now no longer propelled by steam power, but are converted into sailing vessels. I rather think the boats belonging to the Hull Company are not generally used as steam trawlers, as I believe from their large size it would not be profitable to employ them as fishing boats; their occupation would be rather that of steam carriers of fish and ice.

**Spain.**

The first steam fishing boat used on the coast of Spain was built in this country only a year or two since.

**France.**

The French have adopted the use of steam for propulsion of fishing boats and for working steam capstans to a limited extent.

**America.**

In the American waters steam fishing vessels have been engaged for some years with success.

**Reasons of the slow development of fishing by steam power.**

The reasons of the slow development of fishing by steam-propelled vessels is principally due, in my opinion, to faulty design and conception.

For instance, the vessels belonging to the Yarmouth

Steam Fishing Company were built with the idea of using steam as an auxiliary power, looking to the sails as the principal means of propulsion; this I think a mistake, and that rather the sail power should be considered as entirely auxiliary to the screw-propeller, to be used only with a leading wind, or in case of a breakdown of machinery.

If fishing by steam paddle-tugs is profitable, it seems to me to be sufficient proof that steam fishing by a specially and properly designed vessel can be made to pay, as the first cost and working expenses of a boat built for towing purposes would undoubtedly be greatly in excess of that of such a steam fishing vessel.

The consumption of fuel by the ordinary tug engines would be very high, and the general design of a sea-going paddle-tug is certainly not that best suited for fishing purposes. Among other disadvantages may be mentioned the inconvenient height at which they stand out of the water.

But it will be well perhaps now to consider in detail the arguments for and against fishing by steam-propelled vessels.

Arguments against the use of steam fishing vessels.

Those advanced by practical men against, are—

1st. Cost of vessel.

2nd. Increased working expenses over that of sailing-vessels.

3rd. Necessity of returning to port frequently to coal.

4th. Cost of periodical renewal of machinery.

Cost.

The first cost of a steam vessel will certainly exceed, in any case, that of a sailing vessel, because, added to the cost of machinery, the boat itself must be of increased size to allow for space occupied by engines, fuel, &c.

Increased working expenses.

Increased working expenses are principally due, first, to cost of fuel, oil, and stores, necessary for working engines;

second, the necessity to employ a properly qualified engineer, whose wages will considerably exceed that of fishermen.

Necessity of returning to port for coal.

This objection may be considered as answered, as the steam fishing-boat being her own carrier will of course be frequently in port for the purpose of delivering fish.

Cost of renewal of machinery.

Undoubtedly it will be necessary when estimating profits to make a yearly allowance for depreciation of machinery.

Arguments in favour of steam fishing vessels.

The advantages of steam fishing vessels are—

1st. That it is possible to fish over rougher ground than could be fished by sailing vessels.
2nd. Extended choice of fishing grounds.
3rd. The use of steam capstan as a labour-saving machine.
4th. Steam fishing vessels do their own carrying to market with speed and certainty.
5th. Increased seaworthiness.
6th. Power of running for shelter in bad weather, and entering harbours without assistance from tugs.
7th. Steam-vessels can fish in calms and in rougher weather than could sailing vessels.
8th. Steam is available for working a refrigerating apparatus.

Rougher grounds can be fished.

It is well known by fishermen that there are many localities teeming with fish remaining unfished to this day, because of the roughness of the ground.

With steam trawlers, in the event of the net fouling at bottom of sea, the strain upon same can be quickly reduced or altogether removed. The speed while fishing would not be, as in sailing vessels, due to force of wind and currents, but would be at the discretion of the fishermen; therefore it is possible to fish over rougher ground than that fished by sailing vessels, and the rougher the ground the better in size and quality the fish.

**Extended choice of fishing grounds.**

In the North Sea trawl-fishing, with some few exceptions, the vessels fish in large fleets, so that a sufficient cargo is assured to the steam or sailing carriers upon their periodical visits. The choice of the fishing grounds is regulated by an "admiral" of the fleet, whose orders are law in this respect; but the master of a steam fishing vessel will have the option (being independent of the carrier) of fishing wherever he may think best, thus opening up a much larger field for his operations.

It may be said that sailing trawlers ("single boating," as it is called) have this option, but it must be remembered that trawl-fishing is principally prosecuted at 80 to 100 miles from nearest port, and the time in which a sailing vessel ("single boating") might run this distance is entirely uncertain, but with a steam vessel almost certain.

**Carrying with speed and certainty.**

Probably one of the greatest advantages due to the adoption of steam fishing vessels is the facility and speed with which they can carry their own catch of fish to market, thereby avoiding the expensive, time-losing, and very dangerous business of transferring the fish to special steam or sailing carriers.

The advantage of speed in the mackerel fishing is perhaps more especially important, these fish dying directly they are caught, and salt is not, as with herrings, generally used to preserve them on board the boats.

**Seaworthiness.**

It is hardly necessary to say that a well-designed steam vessel is altogether more seaworthy than a sailing vessel.

It is well known that fishermen will hold on to their nets to the last minute, provided they can count with any degree of certainty upon making a harbour within a given time.

In all weathers steam vessels have the great advantage of being able to enter harbour without having to wait for a tug, to say nothing of the saving of expense of towing.

Fishing in calms and in rough weather.

Certainly great advantage must accrue from the steam vessel being able to fish in calms, and in rougher weather, than could a sailing vessel. The speed of a vessel while trawling should be from 2 to 4 knots per hour, and it will be readily understood that the weather is often of a kind which will not allow of this speed being maintained by sailing vessels; but with a steam vessel it may be assured, save in the roughest weather.

Refrigerating apparatus.

The machinery necessary to work a complete refrigerating apparatus for the preservation of fish can be supplied with steam from the main boiler without much additional expense.

The writer, after careful consideration and inquiry, has arrived at the following conclusions with reference to the necessary qualifications of a steam fishing vessel:—

Cost.

1st. The cost of the boat must be as low as possible (consistent with the fulfilment of the following conditions).

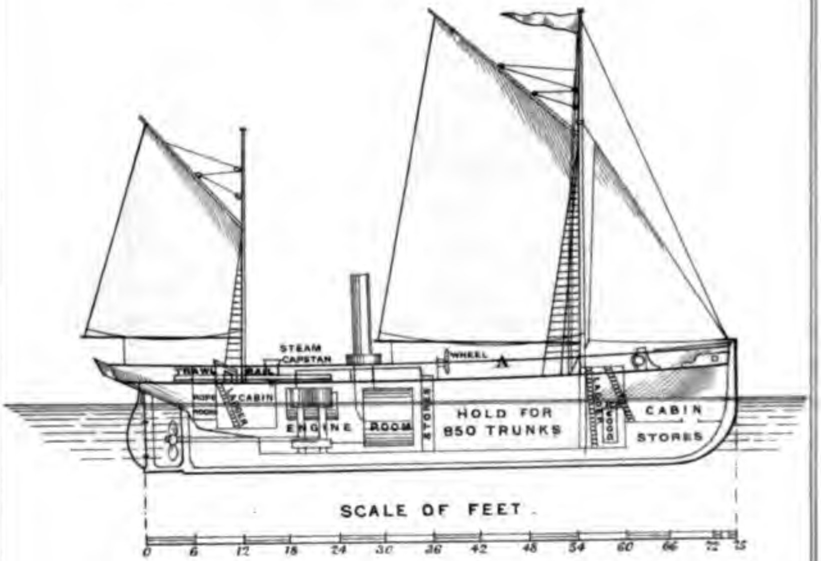
Power, speed, and size.

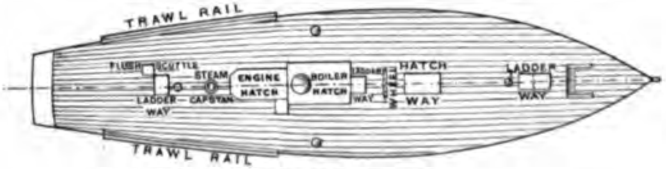
2nd. She should be a full-powered steam vessel, with a speed of not less than 9, or more than 10 miles per hour (this being the most economical speed for steam vessels); her size should be such as will enable her to keep the sea in all weathers if necessary, and yet with a draught of water and general dimensions suitable for small harbours, bearing in mind that increased size means enhanced cost and working expenses. It is improbable, too, that a large boat would catch fish, especially trawl fish, in much greater quantities than a smaller vessel.

Rig.

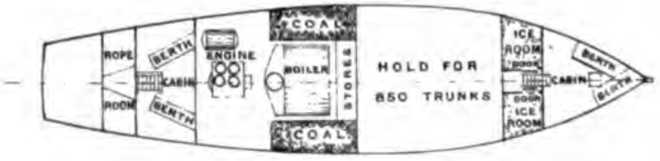
3rd. Fore and aft rig, without any head-gear in the shape of bowsprit, &c., the sails should be only of a size sufficient to handle the vessel upon the event of

# PROPOSED STEAM SCREW TRAWLER &c.





PLAN OF DECK.



PLAN OF HOLD.

a breakdown of machinery, the mast, spars, and rigging thus offering, when the vessel is steaming head to wind, the least possible resistance.

4th. The hold should be of sufficient size to allow of ample ice and refrigerating rooms, including space to carry what might be a week's catch of trawl fish, or a night's catch of drift-net fish. **Cargo.**

5th. The vessel should be easily adaptable for trawl or drift fishing. **Adaptation.**

**Proposed vessel.** The dimensions and particulars of the vessel designed by the writer, a sketch of which is shown on the opposite page, are as follows:

| | Feet. | In. |
|---|---|---|
| Length on load water-line | 75 | 0 |
| Breadth | 18 | 7 |
| Depth of hold | 9 | 8 |
| Draught of water aft | 9 | 6 |
| | Tons. | |
| Displacement in tons (at above draught) | 129 | |
| Gross Register Tonnage | 63·50 | |
| Net " " | 36·60 | |
| Nominal Horse-power | 27 N.H.P. | |

Speed, 10 miles per hour.

About 850 packages of fish can be carried in hold. **Cargo.**

Sufficient space is arranged to stow 7 tons of ice. **Ice.**

Rig dandy, or yawl; it will be noticed that no bowsprit or topmasts are fitted, as the vessel is rigged as a steam vessel "proper."

Capstan worked by separate engine, fitted in engine-room, and supplied by steam from main boiler (see further particulars under head of "Steam Capstan").

Engines of the compound S. C. type.

Boiler of tubular construction, with high working pressure.

**Screw-propeller.** It is arranged that the screw-propeller shall be 2 ft. 6 in. below the water-surface; also when vessel is under canvas only, the former can be disconnected from engines, thus allowing it to revolve freely.

Speed and distances that can be steamed.

Eleven tons of coal can be stowed in bunkers, and attention is drawn to the distances that can be steamed with this supply. Hours, at full speed (10 miles), equal 76 hours, distance travelled 760 miles; at a speed of 7·77 miles per hour, 150 hours, distance travelled 1165 miles; at 5·75 miles per hour, 377 hours, distance travelled 2166 miles.

We will suppose that this vessel is fitted for trawling, and that the fishing grounds are situated 250 miles from Billingsgate.

She could steam at full speed hence, remain there fishing and cruising for a week, and still sufficient coal will be left to allow of boat returning to London at full speed; the time taken for the double journey will be 50 hours.

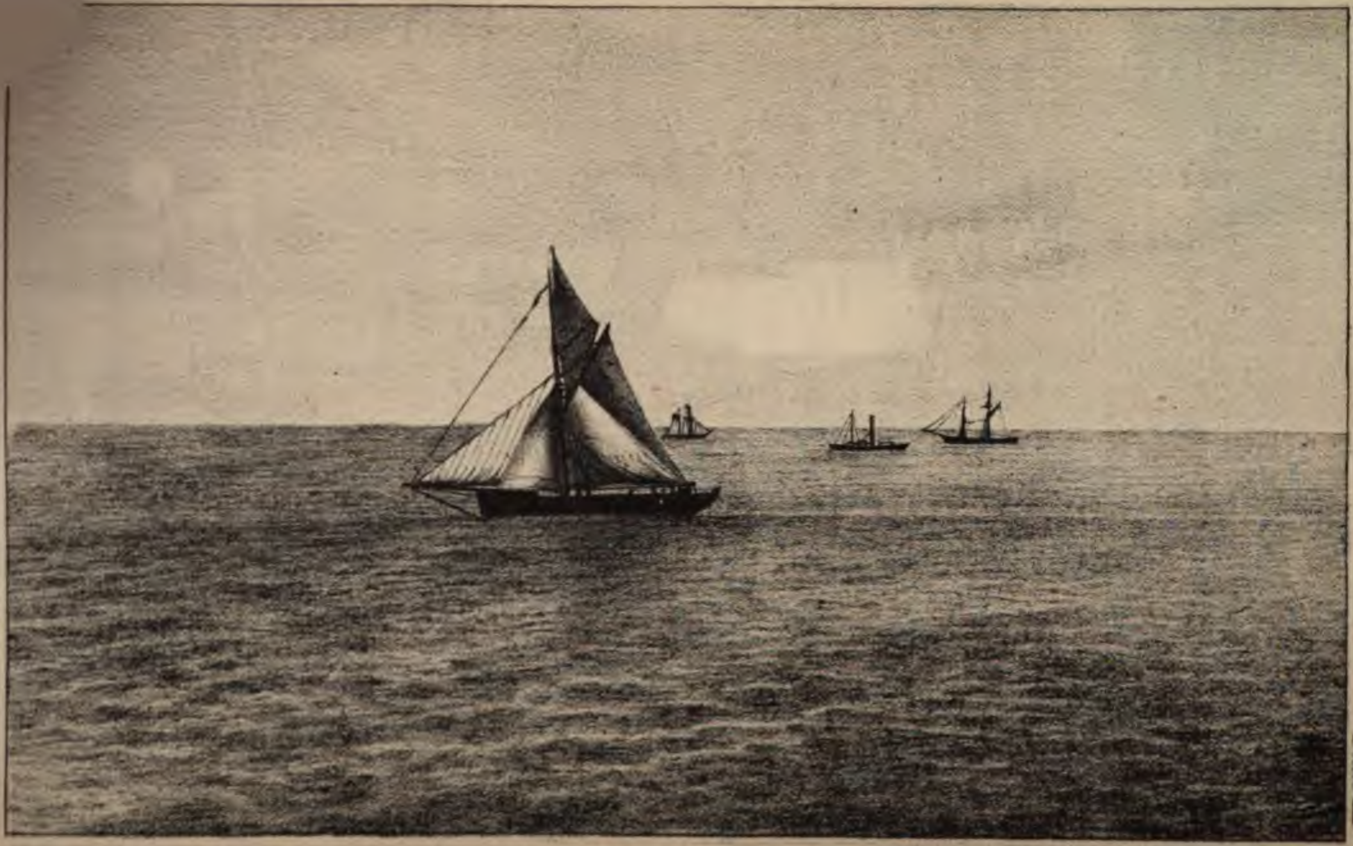
The steam trawlers' catch might be in this case supplemented from other fishing vessels, as it is improbable the former would have caught sufficient fish in a week to make it pay to run such a distance; but as 850 packages of fish can be carried in hold, the freight alone of, say, 750 packages at 2*s*. per package would amount to £75, earned in little over two days, to which must be added the profit upon the fish caught by steam trawler, and the saving in cost of carriage of her own fish.

Again, supposing this vessel is fishing (trawling or drifting) 50 miles from nearest port, the journey hence would, at full speed, take five hours upon a consumption of coal of 14 cwt. only. These examples can of course be varied at will.

With this vessel it would be possible, if convenient, to steam up alongside ordinary fishing vessels in fair weather, transferring the fish caught by the latter to the former, thus avoiding the use of small boats.

X.–10.

Plate III.



EAST COAST SAILING TRAWLER.

Cost. And last, but certainly not least, we have here a steam fishing vessel at a reasonable cost, as she could be built and fitted complete, ready for sea, for the sum of £3000.

Design. The object kept in view when designing has been to depart as little as possible from the dimensions and internal arrangements of the largest type of sailing fishing vessels, for I think the change to steam should be as little marked as possible.

We will therefore now compare this proposed vessel with the existing sailing fishing vessels.

1st. The dimensions are only exceeded in that of length, due to space required for engines and boilers.

2nd. The draught of water is the same, also the height out of water.

3rd. The quantity of fish carried is equal to that by the largest sailing fishing vessels.

4th. This vessel is shown built of wood; thus the steamers can still be built at the same places, and by the same builders as heretofore.

In advocating the general adoption of steam fishing vessels, we must remember that steam fishing will greatly alter the character of the occupation.

The business of fishing, as now prosecuted, is peculiarly uncertain. With the help of steam, the departure and return to port can be estimated within an hour or two. "Time and tide wait for no man," but by steam both will be practically conquered. Disasters by storms to our fishing fleets, which we now so often and so much deplore, may to a great extent be avoided.

Fish, which must be fresh to be relished, will then probably be at all times obtainable, instead of, as now, "a feast and a fast."

Loss of life in ferrying from "catcher" to "carrier" will be stopped, and we have the engineer here as the deliverer, to a great extent, from the troubles that have hitherto inevitably followed our fishermen.

## STEAM CAPSTANS.

Steam capstans are now used on fishing boats belonging to France and other countries, besides on our own coasts, and their number is undoubtedly increasing daily.

**Advantages.**

The advantages obtained by their use are :—

1st. Speed in getting nets on board (and only those acquainted with this tedious operation can have any idea of the superiority of steam over hand-power capstans).

2nd. The possibility of getting the nets when it would be impracticable by hand capstan.

3rd. A reduction in the number of crew.

4th. The general hauling work of the boat being facilitated, such as hoisting sails, getting anchor, small boat, &c.

5th. The engine can be used for pumping purposes, from bilge into sea.

**Design of capstan.**

It may be well to point out the most desirable objects to be secured in the design of a steam capstan. They are taken to be the following :—

1st. General compactness.

2nd. Working parts of engine to be kept below deck.

3rd. The capstans should be so arranged that the barrel shall revolve at various speeds, while maintaining at all times, if desired, the maximum power.

4th. Engines, by a simple arrangement, to be controlled from the main deck.

5th. Working parts on deck to be covered.

6th. Boiler to be as small as possible, working full power with the least consumption of coal, and it should be placed under the main deck.

7th. Engines to disconnect, to allow of capstan being worked by hand if necessary.

Withal, simplicity of design, as it must be remembered that fishermen are generally taken from a class unacquainted with machinery. And I am told that the fact of it being necessary to employ an engineer is one of the principal drawbacks to the almost universal adoption of steam capstans on fishing boats (for undoubtedly they are highly appreciated, both by owners and men). Of course, added to the above objection is that of first cost.

Cost.

The latter may be taken as being from £150 to £200 on a large sailing fishing boat, a considerable addition to the cost of hull, and outfit, which would be from £1200 to £1500.

It will be seen that the above problem is considerably simplified in a steam-propelled fishing vessel.

The feasibility of using the machinery of the capstan engine, for the further purpose of propulsion of vessel, has been considered, but my confident opinion is that this plan would be extravagant, and generally impracticable, as the actual power required to drive a capstan is very small ; too little, in fact, to be of use to propel the vessel, and to augment the power sufficiently to drive the boat, at even a very moderate speed, would enhance the cost of machinery fourfold, and after all, at best, we should have that most unsatisfactory of perhaps all marine inventions, an auxiliary steam vessel, as the power would not be sufficient to drive the boat at a paying rate, without great assistance from sails.

With reference to the use of steam power in fishing vessels, I conclude that either a sailing vessel may be fitted with a steam capstan, or the boat should be one capable of being propelled at a good working speed, say of not less than nine miles per hour, quite independently of sails, and then the capstan may be worked by steam supplied from the main boiler.

### ADVANTAGES OF STEAM CARRIERS.

Duty of.

Steam carriers I understand to be vessels propelled by steam power, used for conveyance of fish from the deep-sea fishing boats to the port or market. These vessels have hitherto been almost entirely employed in carrying trawl-fish, as the practice has been for drift fishing boats to take their own catches to the nearest port.

Ferrying.

The trawl-fish, when caught, is ferried in small rowing-boats (attached to the trawlers) to the carriers, which, upon completion of their cargo, proceed with all speed to market.

In passing, some notice may be taken of this ferrying business. The boats engaged in this work are certainly well and strongly built, but they are necessarily heavy and cumbersome. Their dimensions are about 16 feet length by 5 feet 6 inches beam; rowlocks are provided for four rowers, whose work is attended with great risk in bad weather, many a poor fellow being drowned on this duty, owing to the boat being upset, or stove in, when coming alongside.

Advantages.

Among the advantages gained by the use of steam carriers are:—

1st. Almost certainty of delivery of cargo within a given time.
2nd. Fish not so frequently handled in transit.
3rd. Non-exposure to sun and rain.
4th. Facilities for preservation of fish on board.
5th. Superior condition in which fish is delivered at market.
6th. Consequent readier sale, and better price.
7th. Carriage by steam carrier far cheaper than by rail.

**Almost certainty of delivery within a given time.**

Great advantage is ensured in delivery, in comparison with carriage by sailing carrier, or sailing carrier and rail combined, and I will endeavour to show that even the latter means is not very superior to direct carriage by steam carrier with respect to speed.

Take, for example, the following. Fish coming by rail from Yarmouth is first sent by sailing carriers to that port from the fishing grounds, the time taken being necessarily very uncertain, according to the direction of the wind and state of the weather; they may be hours, or even days, making port. Upon the arrival of carrier at Yarmouth, the fish is transferred to railway trucks, and if its destination be Billingsgate, despatched to London. Upon its arrival there it has to be unloaded into horse vans and carted through streets, the time taken in transit being more or less, according to the greater or less congested state of the traffic and approaches to the market.

Now, assuming smacks are fishing 80 miles from Yarmouth, it would take, at the least, nine hours for sailing carrier to get to that port, another two hours to unload and load into railway trucks—six hours, say, to make the journey to London, and an average, say, of two hours to get from railway station into Billingsgate; this is the lowest estimate (it having been proved that the time varies from one to six hours). We have thus nineteen hours as the time taken to get from fishing grounds to Billingsgate Market.

Now, supposing fishing grounds are situated 200 miles from London,* a steam carrier should do this distance in twenty hours, thus taking one hour longer than by above route. At the best, it will be seen that the time of delivery of fish by sailing carrier and rail is quite uncertain; but by steam carrier, save in the roughest of weather, the actual time can be estimated within an hour or two.

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* This will be about the relative distance supposing that smacks are fishing *80 miles off* Yarmouth.

**Handling of fish.**

Fish then delivered into Billingsgate Market from steam carrier is only handled twice—i.e., from the smack into carrier, and from the latter into market. That coming by rail is handled four times—i.e., from smack into carrier, from the latter into railway truck, from truck into horse vans, and then into market.

**Non-exposure to weather.**

Fish is certainly acted upon prejudicially by sun and rain; in the hold of a steam carrier they are preserved almost entirely from these influences.

Some idea of the superiority of water carriage of fish will be realised when we note, from official returns for February, 1883, that out of 9600 tons of fish brought to Billingsgate 1984 tons were water-borne; but while 4½ tons were condemned as unfit for human food, only 2 cwt. of that quantity came by water, which equals 0·046 per cent. of land-borne fish condemned, against 0·005 per cent. sea-borne. From the returns of fish delivered and condemned at Billingsgate Market, from September, 1880, to June, 1881, I find that in this time 64,763 tons of land-borne fish were delivered at Billingsgate Market, against 28,958 tons by water. Of the former quantity, 330 tons were condemned, against 64 tons of the latter, which equals 0·509 per cent. land-borne, and 0·22 per cent. water-borne fish condemned. But it must be noticed that the return does not include the hottest part of the year, when land-borne fish would be liable to deteriorate most.

**Fish easily preserved on board steam carrier.**

A great advantage is the ease with which the operation of "icing" can be performed on board the carrier while the vessel is under way. But better still would be the general introduction on board these vessels of refrigerating apparatus, for besides preserving the fish on the passage from fishing fleet to market, should it arrive at market after it is closed, it can be kept on board till the following, or if on Saturday, till the Monday morning; and it is the fact that the greater part of fish condemned at Billingsgate is on the Monday.

Little extra expense need be incurred from the use of refrigerating apparatus, save first cost, as the steam for working the engine can be supplied from main or donkey boiler. By this means large quantities of fresh fish can be obtained from distances it would be otherwise impossible to bring them.

**Superior condition in which fish is delivered.**

For these reasons fish coming by steam carrier direct from fishing grounds can be, and is, delivered at market in much better condition than that transported by railway, and it consequently invariably commands a readier sale and a better price.

According to evidence given before the Fish Supply Committee of the City of London Corporation, it was proved that sea-borne fish realises on an average 25 per cent. higher price than rail-borne fish.

**Relative cost of carriage b steam carrie and by rail.**

Fish is brought to London direct by steam carriers from fishing fleet belonging to Hull, a distance, say, of 400 miles, for 1*s.* 6*d.* per package freight; but should the steam carrier deliver its cargo at Hull, the railway rate from the latter place to London would be not less than 1*s.* 6*d.* per package, the distance being 175 miles.

Added to this railway charge must be the cost of freight, by steam carrier, from fishing fleet to Hull, which is 9*d.* per package.

The cost, then, of bringing the fish by steam carrier direct to Billingsgate would be 1*s.* 6*d.* per package, but by rail and steam carrier combined 2*s.* 3*d.*, an excess in cost of carriage by the latter system of 50 per cent. over the direct carriage by steam carrier, beside all the disadvantages attending the transhipment.

Again, Messrs. Hewitt, of Billingsgate, charge for freight by their steam carriers an *ad valorem* rate, viz., one-fifth of what the fish realises; but if they carry for boats other than those they sell for, they generally make a charge of 2*s.* per package freight from fishing fleet to Billingsgate.

Now if this fish (caught 50 to 100 miles off Yarmouth) was sent into that port by sailing carrier, there being no steam carriers going into Yarmouth,* the charge for freight per package would be 1*s.* 6*d.* Add to this the railway charge from Yarmouth to Billingsgate, delivered, taken at an average of 1*s.* 8*d.* per package, the total cost would be, from fishing grounds to Billingsgate, *viâ* Yarmouth, 3*s.* 2*d.*, against 2*s.* by steam carrier direct; difference, more than 58 per cent.

It will be seen from these figures that, on the score of cost of carriage to market, the balance is decidedly in favour of steam carriers.

Possible employment.

But there are many other places between which steam carriers might profitably work. First, I would mention the Irish south-east and south-west coast; from Baltimore alone it has been stated that from 50 to 100 tons per week of mackerel could be supplied during at least four months of the year, and this quantity is but a small part of the whole available supply from adjacent fishing centres. These mackerel are now generally sent by way of Cork, Dublin, and Holyhead to London (a sufficiently roundabout route necessitating it being carted three times) at a cost of 10*s.* per box weighing 2 cwt., or £5 per ton carriage and delivery at Billingsgate. Sent by ordinary steamer, if available, direct to Milford, and thence by rail, the cost is £4 per ton into Billingsgate.

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* Since the above was written, Mr. Burdett-Coutts has introduced steam carriers for the purpose of carrying fish from the North Sea fishing fleet into Yarmouth.

Now if a steam carrier came direct to London round the Land's End, the distance would be 600 miles. We have shown that fish is carried by steam carriers a distance of 400 miles for 30*s.* per ton; therefore, at this rate, it would cost 45*s.* per ton from Baltimore and south-east coast of Ireland to London by sea, and the time taken to perform the journey should not exceed sixty hours, delivered into Billingsgate, an excess in time of only twelve hours if sent by present route. But, properly preserved by refrigerating apparatus, or even by ice, I believe the fish would be delivered in really better condition. Anyhow, properly designed steam carriers, during the season, could be profitably employed running between Ireland and the English west coast ports. With reference to the supplies of fish available from Ireland, it is interesting to note that, according to the *Standard* of March 22nd, 1883, 100 tons of mackerel were caught off the "Shannon" on the night of the 21st of March, being of the estimated value of £6000.

From the coasts of Norway large quantities of salmon and cod can be procured. It has been estimated that about 3,000,000 lbs. weight of cod is annually caught on the coast of Finmarken and around the Lofoden Islands, the principal part of which is now salted and sent to Spain and other Catholic countries.

What is wanted to secure at least a part of this catch, is undoubtedly a good service of well-appointed steam carriers, so that these fish, otherwise salted, might be distributed over England and the Continent in a fresh condition. Supplies of fish can also be obtained from Heligoland, distant from Grimsby 295 miles, and from London about 400 miles, and many other continental fishing stations too numerous to mention.

But, coming nearer home again, steam carriers might work down the coast from Scotland, collecting fish for London market or elsewhere.

Thousands of tons of fish are even now, under the present imperfect system of carriage (being carried on the deck of the steamers), exported from England to Antwerp, Rotterdam, Paris, &c.

A greater part of this fish might be sent direct to these places from the fishing grounds, instead of, as now, first brought to some English port and afterwards reshipped abroad.

Large quantities of salmon and cod are now imported from Nova Scotia, Labrador, New Brunswick, Columbia, &c., the far greater part of which is salted or tinned. From a report I glean that the total number of cases exported in 1881 from Columbia was 530,000.

The number of boats engaged in these fisheries was 1650, including 10 steam sloops, and the number of salmon caught in 1881 was about 3,300,000.

There are other salmon fisheries, almost as prolific, in the Red River, the water of Puget Sound, and the Alasker.

It will be seen that the supply is practically unlimited from these places. By means of steam carriers fitted with refrigerating apparatus, similar to that used on vessels bringing meat from America, we might secure the best of fresh salmon at a cost to the consumer that would allow of ordinary people sometimes tasting this delicious, but now impossible fish.*

**History.** Messrs. Hewitt, of Billingsgate, were the first to build steam vessels for the special purpose of ferrying fish from fishing-grounds to market. This was about eighteen years ago.

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* The vessels for this service would require to be larger than those described.

Previous to the year 1864, part of their fish was landed at Yarmouth, and thence sent on by railway, and some was sent to Gravesend in "well" vessels, and thence to Billingsgate by "hatch" boats; now all, or nearly all their fish is brought to London by steam carriers.

In 1881 these steamers (eight in number) brought 376,426 packages of fish to Billingsgate Market.*

Little or no advance seems to have been made in carriage by steam carrier, until in 1880 the Hull (Fish) Carrying Company was started. In 1881 they were regularly employing 4 steamers bringing fish direct to Billingsgate Market from fishing-grounds; in twelve months they delivered about 300,000 packages of fish.

Another company was started at Grimsby for the same purpose, and from January to August, 1880, with 4 steamers, they delivered 165,000 packages at Billingsgate, and 38,408 at Grimsby. I have mentioned already the Yarmouth Steam Trawling and Carrying Company, and my opinion of the reason of this company's want of success as a steam trawling and carrying company; but it must be noticed that these vessels were not at all of the same class as those just spoken of.

At Scarborough, on the Tyne, and elsewhere, steamers have been employed in catching and carrying fish, but I have not heard of any steam carrier proper being used there.

**Dimensions and particulars.**

The vessels employed as steam carriers by Messrs. Hewitt carry about 3000 packages of fish when loaded, equal, say, 150 tons dead weight of fish, besides ice, &c.

They are "ketch" rigged, and are propelled by a single screw propeller. The engine and boiler are placed well aft, and a bridge is fitted before the funnel on which is the steering gear. These boats have a great deal of "sheer" to the main deck, being low in the water just abaft the middle of length, for the purpose of facilitating the transfer of fish from the small ferrying boats coming from the smacks with fish, and are high out of the water forward, for seaworthiness.

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* The average weight of each of these packages of fish may be taken to be 1 cwt.

I believe some of these carriers are fitted with refrigerating apparatus.

The dimensions of a boat belonging to the Hull Steam Fishing and Ice Company, Limited—a model of which was exhibited at the Shipwrights' Company's Exhibition, 1882, and which was awarded a prize—was as follows:—Length, 130 feet; breadth, 21 feet; depth, 11 feet; the horse-power being 60 nominal. The ice room is situated in the forward part of ship; length of hold about 40 feet. The same was separated from engine and boiler room by a space occupied by coals, and the engine and boilers were placed well aft; ketch rigged, steering from bridge, and fitted with steam windlass and winch.

The cost of a vessel of this size should be about £6000, and the speed about 9 knots, upon a consumption of coals of about 7½ tons per day of 24 hours; and the time it would take to get from the Hull fishing fleet, about 48 hours at full speed.

Earnings.

Now it has been shown that these four steam carriers belonging to Hull delivered 300,000 packages of fish at Billingsgate Market, equal to 75,000 packages each boat. The freight per package to Billingsgate charged is 1*s.* 6*d.*, which would give the gross earnings of one boat for one year as £5625. The working expenses of this boat would be, say, £80 per week, equal to £4160 per year, showing a profit of £1465 per annum, equal to 24·4 per cent. upon the estimated original cost of one boat, i.e. £6000.

It will, perhaps, be well to consider what are the most desirable features in a well-designed steam fish carrier, and they are taken to be the following:— **Design.**

1st. Reasonable size. Too large a vessel is unprofitable, as from the uncertainty of the supply of fish from the smacks, at times the carrier must run to market with but part of a cargo. Again, the working expenses of steam vessels increase rapidly with enhanced size, and generally a small boat is more suitable for the purpose.

2nd. The speed should be about 9 knots per hour, this being the most economical speed for steam vessels; and engines of the most approved type should be fitted with special reference to the reduction in consumption of coals.

3rd. It is recommended that sail power should be considered as quite auxiliary to the steam power.

4th. Ample space should be provided for ice.

5th. The vessel should be of such a height out of water, consistent with seaworthiness, as will allow of the small boats ferrying fish from smacks doing so with the greatest possible facility.

6th. Special attention should be paid to the fitting up on board of the most approved refrigerating apparatus, as it is believed that in this particular the greatest improvement in conveyance of fish by steam carrier is to be made. Arrangements should be made for working the refrigerating apparatus by steam power supplied from main or donkey boiler, avoiding the extra expense of a special boiler for the purpose. I think a suitable refrigerating room with engine could be fitted up complete in such a boat for, say, £400.

It might be well to provide large iron tanks similar to those now used by certain railway companies. They hold about 2 tons weight of fish, and could be filled at sea with, perhaps, "offal" fish, and lifted out by steam winch when **Tanks.**

at market, and afterwards returned to the vessel. This would save a great deal of packing and handling of fish, and the cost of returning to vessel so many empty boxes.

**Steam launch.**

There is one other point, and I have finished my remarks upon "steam carriers," and that is, the suggestion that they might be supplied with a steam launch. The same could be used for towing the smack's rowing-boats, loaded with fish, to the carrier, thus saving time, and, we think, minimising the danger of this work; or, in bad weather, it might be better for the launch to do all the ferrying, collecting the fish from the various fishing craft.

## GREATER FACILITIES TO BE GIVEN BY RAILWAY COMPANIES IN REGARD TO RATES.

The question of railway rates is one that has constantly exercised the mind of the commercial community. This is shown by the frequent appointment of Parliamentary Committees of Enquiry, the latest of these being the one of 1872 (following upon which was the Act of 1873 appointing the Railway Commission), and the Select Committee of 1882, upon the report of which further legislation is promised.

I do not propose to recapitulate in full the conclusions arrived at by this last Committee, but shall take occasion, so far as it affects my present subject, to notice them.

**Do railway companies grant every facility?**

And first, I ask, do the railway companies generally grant every facility, by means of cheap rates, for the carriage of fish? And this I must answer in the negative.

It would appear that, although the railway companies are granted an immense monopoly as carriers, that they seem to look at the question of rates almost entirely from a shareholder's standpoint, viz., whether the particular rate they charge to any given place, and for any special kind of goods, will yield such a profit as will allow of a good dividend. Their demands are generally only modified in accordance with the amount of competition they have to fear.

**Complaints against railway companies.**

But I will proceed to consider the various reasons for complaints against the railway companies. From the Report of the Select Committee of 1882 it would appear "That rates in excess of the maximum authorised by the special Act are in many cases exacted."

**Recommendtion of Railway Committee (1882**

With reference to this charge, the Committee state that the railway companies admit the rates sometimes are in excess of the maximum authorised; that is, if the mileage rate alone is taken into account; but they consider themselves entitled to make a charge for "terminals," that is, for accommodation and services performed by them at the receiving and delivering stations. The conclusion the Committee arrive at upon this point is, that "The right of the companies to make this charge for 'terminals' should be recognised by Parliament, under the condition that the amount be entered in the rate book for the guidance of the public."

2nd. Another complaint is, that on the same line of railway higher rates are charged on some kinds of goods as compared with others, without apparently sufficient reason. Undoubtedly there appears to be cause for this complaint, and I take the following from many examples. Between Whitby and London, the rate per ton for beer is 28*s.*, and for hams and coffee, 30*s.*, but for fish it is 40*s.* per ton; meat is carried by rail from Holyhead to London for 25*s.* per ton, but the rate for fish is 55*s.* per ton.

With reference to this, the Railway Committee (1882) concluded "They could not recommend any new legislative interference for the purpose of enforcing upon railway companies equality of charge," one reason, among others, being that these charges may really prove beneficial to the community at large.

In many other cases of complaint the Committee did not arrive at any conclusion, or rather, they did not indicate the way out of the difficulty, thus showing how difficult a subject this is; but their recommendations may generally be summed up in their proposal, that further powers should be granted to the Railway Commission, so that all these questions may be gone over before the latter body and adjudicated upon.

**Advantage to railway companies of quick despatch.**

It may be said that the necessary prompt delivery of fish enhances the cost of its transit by rail, but quick despatch must also be advantageous to railway companies, as their trucks are the sooner available for further duty. Some goods remain in trucks for days before they are delivered.

**Difference in rate for "prime" and "offal" fish.**

It is noticeable that most railway companies make a considerable difference in the charge for carriage of the two classes of trawl fish—i.e. the "prime" and the "offal." For example, the rate per ton from Yarmouth to London for "offal" fish is 20*s.* 10*d.*, but for "prime," 34*s.* 2*d.* Now, speaking generally, the cost of transit to the railway companies is the same, the exception being when the former is sent loose in trucks, for which a special reduced rate is usually quoted. It seems that there is not sufficient reason for the two different charges, and the only explanation I can find for it is, that the railway companies are of course aware of the fact that the "prime" fish realises a higher price than the "offal," and that the former can consequently afford an enhanced rate.

I note, however, that by both steam and sailing carriers the freight is the same for all kinds of fish.

But it may be thought the "offal" fish is carried at a ry low rate by the railway companies; this is not the

Cost of transit to railway companies.

case, as will be seen from the following figures. It may be taken that railway companies can profitably run goods trains for 5*s*. per train per mile. Now the rate for "offal" fish from Yarmouth to London, station to station, is 20*s*. 10*d*. per ton, the distance being 120 miles. Supposing the weight in a given fish train, carrying *only* "offal" fish, is 50 tons,* we shall have the freight earned on this trip rather over £52.

Now 120 miles at 5*s*. per train per mile equals exactly £30, the sum for which 50 tons of fish could be profitably carried by rail this distance. Therefore, it is shown that the profit in this case is £22 over and above that which is included in the estimate of 5*s*. per train per mile.

To justify this estimate, I may state that the charge for a special fish train from Yarmouth to London is £32. I have given this particular example, as the exact figures are before me; however, the result may be taken to be about the same when this test is applied to the fish rates of other railway companies.

It is possible for railway companies to reduce their rates.

It will be seen, then, that it is possible for railway companies, if they are so inclined, to reduce their rates for the carriage of fish, and yet leave themselves a good margin of profit.

Cost of carriage for long and short distances.

Another matter deserving attention is the relative cost of carriage for short and long distances. Undoubtedly, a low rate per ton per mile for long distances is to the advantage of those sending fish a long way.

According to the Report of the Railway Committee (1882), the railway companies admit that the lowest rate they charge is a profitable one.

Using the same figures as before, we will see how much the rate per ton per mile for a short distance exceeds that for a longer one. We have, then, "prime" fish conveyed from Yarmouth to London for 34*s.* 2*d.* per ton, the distance being 120 miles; this will equal 3·41*d.* per ton per mile; but from Yarmouth to Norwich, 20 miles, the rate for "prime" fish is 10*s.* per ton—equal 6*d.* per ton per mile. Space will not allow of my giving other examples. But it seems that this difference is excessive, even allowing for the fact that the consignments to London are larger and more regular. Undoubtedly, under the present system of encouraging a traffic in fish to distant cities, such as London, Manchester, &c., to the almost exclusion of smaller places, all concerned suffer; 1st, the fisherman, whose returns must be reduced from the increased cost of carriage (due to the distance); 2nd, the consumer, who does not live in these large centres; 3rd, the railway companies, who, to secure the traffic, must carry the fish at a minimum rate.

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* Fifty tons is a very low estimate.

The remedy appears to be the encouragement by railway companies, by means of low rates, of a regular traffic from the fishing stations to the nearest towns situated on their systems. And it will be well if local authorities should grant every facility, by means of improved markets, &c., for the sale and distribution of fish in their respective towns, instead of, as now, allowing the greater part to pass by them on its way to London and other large cities. The result would certainly be a better distribution of fish.

**Difference of charges of various railway companies.**

There exists a great difference between the rate charged for the carriage of fish by different railway companies.

For instance, "prime" fish is carried from Yarmouth to London, station to station, as before stated, for 34*s.* 2*d.* per ton, while the rate from Ramsgate to London, station to station, is 35*s.* per ton; that is to say, by one company fish is carried 120 miles for 10*d.* per ton less than another charges for only 86 miles. Again, while fish is brought from Scarborough to London at the rate of 2·81*d.* per ton per mile, that from Ramsgate costs 5*d.* within a fraction.

**Lowest existing rate.**

The lowest existing railway rate for fish I know of, is 1·77*d.* per ton per mile, while the highest equals about 6*d.* per ton per mile. It must be explained that the former is for the greater, while the latter is for the shorter distance, but, taking the average distance, the average railway rate equals about 3*d.* per ton per mile.

**Will low rates reduce price of fish?**

But it is argued by railway companies that reduced rates of carriage would not appreciably affect the selling price of fish. Upon first sight this seems plausible, for, taking the existing rates per ton and dividing it by 2240 pounds in a ton, we have the cost of carriage per pound as only a fraction of a penny; but, in dealing with this question, it must be remembered that often the margin of profit to the fishermen is very small.

**Rates compared, viz., by rail and steam carrier.**

Mr. R. Hewitt, in his evidence before the Parliamentary Committee of Enquiry into the proposed Shadwell Market, gives an interesting example of this. He mentions a case within his experience in the year 1881, in which twenty-five boxes of fish were sent by rail to London; the amount they realised was 51*s.* The total expenses were 96*s.*, showing a loss of 45*s.* to the fishermen. He, Mr. Hewitt, further stated that if these fish had been sent by his steam carrier direct to Billingsgate Market, the total expense would have been 25*s.*, showing a return to fishermen of 26*s.* Now it will follow, if the latter find that the expense of transit to market thus absorbs their profits, that they will not send the quantity they otherwise would; and indirectly, therefore, the consumer suffers from high (fish) rates for carriage, as he will probably pay a higher price for his fish in proportion to the reduced supply. It was actually given in evidence before the same Committee, by the master of a fishing vessel, that he had at times received instructions from his owner to send only the "prime" fish to market as the "offal" would not pay for the carriage; the consequence was, he threw overboard the "offal" fish caught, sending only the "prime" fish. Nothing further hardly need be said to show the importance of cheap rates.

Destruction of fish.

Weight charged for by railway companies.

The weight charged for by railway companies includes that of the fish box, and ice in same. A witness before the Fish Supply Committee of the Corporation of London, 1881, said that the actual weight of fish carried by the railway companies did not amount to more than half of that charged for. He complained of the rough handling of the fish by the railway companies, necessitating the fish being packed in very heavily made boxes, and he estimated that the weight of box and ice was equal to the weight of fish in box.

This witness also complained of the delay in the railway service, stating that Kinsale mackerel was often sent to London by coal train, which he considered was neither a good or proper service for fish. Complaints have also been made that fish is often sent in dirty cattle trucks, thus arriving in anything but a clean condition.

Various kinds of trucks.

But upon some railways specially constructed trucks are provided for the carrying of live fish. These trucks are fitted with portable iron tanks, holding about 2 tons. They are filled with water, in which the fish, principally cod, is placed upon the arrival of truck at destination. The tanks are lifted out and placed in horse vans, and taken to market. The Manchester, Sheffield, and Lincolnshire Railway Company provide these tanks for their London traffic only.

It will be seen that the use of tanks filled with water for the carrying of fish must be an expensive method, as the weight of water carried must add to the cost of transit.

Vans have been used, at least by the Great Northern and Great Eastern Railway Companies, of the following description. They are horse vans; after being loaded they are placed on open trucks and secured. At the end of journey they are removed from trucks, horsed, and taken through the streets to market. I believe this system, however, has almost entirely fallen into disuse.

It has occurred to me that possibly the railway companies might have cause for complaint against consigners of fish, and that they might point out ways in which the latter could so far facilitate the despatch as to allow of the former lowering their rates. I addressed several railway companies on this subject, but in answer no complaints were made, nor any suggestion given upon this point.

## REFRIGERATING VANS.

I cannot learn, after making many inquiries, that refrigerating vans for the special conveyance of fish have as yet been used by any of the railway companies, but must express the strong opinion that in this direction a decided movement should be made, the advantages to be derived from their use being so great to all concerned.*

To railway companies, because the despatch now necessary would not be so essential, an hour or two making no difference then in the quality of the fish. **Advantages.**

To merchants, as they might depend upon their fish getting to market in good condition, and to the public in the better quality of fish supplied.

Fish may be carried in a refrigerating van any distance with perfect success, thus allowing larger supplies to be drawn from great distances, and practically bringing the more distant fishing stations into competition with those situated nearer to the large cities and towns.

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* Since the above was written, "Knott's" Refrigerating Railway Cars have been used for the conveyance of fish from Scotland and elsewhere to London.

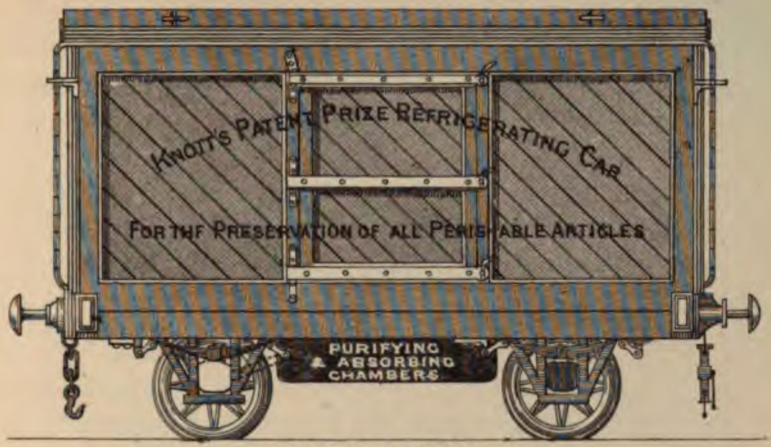
One great advantage in the use of refrigerating cars is that, whatever the time of arrival at their destination, the fish may remain in the cars, provided there is siding accommodation, till wanted, without losing in quality.

As will be seen from the following description of what is, perhaps, one of the best systems as applied to refrigerating cars, the first cost will not exceed £50 over that of an ordinary fish van with the same carrying capacity, an inconsiderable excess compared with the advantage of the former over the latter.

**Refrigerating van.**

In 1879, the year of the Royal Agricultural Society's show at Kilburn, the Lord Mayor of London and the Mansion House Committee offered a prize of £50 and a gold medal for the best means of conveying meat, fish, &c., by railway on a journey of 500 miles, the temperature of the van not to exceed 40° Fahrenheit, and the goods to remain in same for six days.

The prize was secured by the Swansea Waggon Company, Limited, for a van built by them, and fitted upon the principle known as "Knott's Dry Air System." After being stored with meat, game, &c. (no mention is made of fish, although of course the result would be the same) it was closed on June 19th, in presence of the Judges. It then ran the journey from London to Holyhead and back, and afterwards stood in the Royal Agricultural Society's grounds at Kilburn until the 28th (nine days). When opened, not the slightest taint or odour was perceptible, and the surface of the goods was as dry, sweet, and sound, as could possibly be desired.


KNOTT'S PATENT PRIZE REFRIGERATING CAR
FOR THE PRESERVATION OF ALL PERISHABLE ARTICLES
PURIFYING & ABSORBING CHAMBERS

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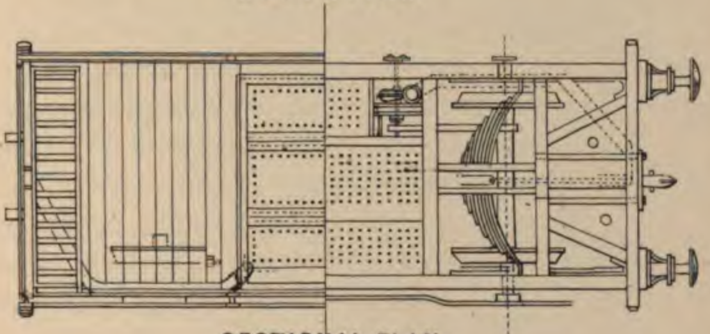

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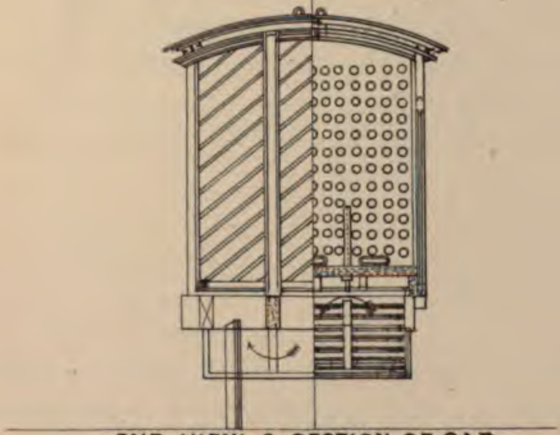

END VIEW & SECTION OF CAR.

The car was again closed till July 2nd, with the same result upon inspection.

The principle of the invention is to make the car itself perfectly air-tight, and then by means of tanks containing ice to bring the temperature down to, say, 33° Fahrenheit.

Within the car a fan, or blower, is fixed, by which the enclosed air is circulated and purified by passing through charcoal. When running, the blower is worked by means of a strap passing round the axle of the waggon wheels, and when standing, it can be worked by hand.

It is considered by inventor that there is no necessity to work the fan when the car is at rest, unless it be so for a very long time, as the air has already been thoroughly purified while the car was in motion.

**Dimensions.**

The general dimensions of the ordinary car, the outside appearance of which is very similar to the common railway van, is as follows: Length outside, 19 feet; width, 7 feet 6 inches; height, 6 feet 4 inches.

In this system it must be noted that the contents of the car are not actually frozen. The temperature recommended being 33° Fahrenheit, it is a "cold, dry air," not frozen air, in which the goods are preserved.

One of these cars was exhibited at the National Fisheries Exhibition at Norwich, and was awarded a prize of £20.

**Cost.**

The cost of one complete is only £200, or about £50 in excess of that of an ordinary fish truck of similar carrying capacity.

I am indebted to Robert D. Burnie, Esq., Managing Director of the Swansea Waggon Company, for the information which has enabled me to describe this particular system as applied to railway vans.

He informs me that his Company propose exhibiting one of these cars at the forthcoming Great International

Fisheries Exhibition, and I have had the opportunity of suggesting to him, in answer to his request, the best way of fitting up his car for general fish-carrying purposes.

## NEW AND IMPROVED FISH MARKETS, AND COLD STORAGE ROOMS FOR SAME.

My previous remarks have had reference only to the economical transmission of fish by sea or rail, or by both combined, from the fishing vessels to the various markets; that is to say, we have been dealing with the question of the wholesale trade supply of fish. But now we come to consider the subject of the better distribution of fish to the actual consumers, not only to those that can afford to pay any price that may be asked of them, but to the million. And I take it the first condition necessary to ensure the proper distribution of the produce of our fishing-grounds is that cities and towns should be possessed of far superior fish markets than they are now generally provided with.

**Distribution of fish.**

In treating of the distribution of fish, we must bear in mind the very perishable nature of the article, and the necessity for immediate distribution to the actual consumer, after the fish has once left the sea.

In the first place, therefore, I will inquire into the available modes of distribution.

**Number of markets.**

Markets have been, in all ages and times, the great means of distributing articles of all kinds; but when we think of London, with its 4,000,000; Liverpool, 550,000; Glasgow, 512,000; Birmingham, 402,000 inhabitants, we see that to expect one market in each of these cities to supply properly such a number of people is absurd. I therefore come to the conclusion that more than one fish market is required for all towns of over, say, 100,000 inhabitants. But then comes an objection from the "trade," who protest upon the ground (and a very reasonable one too) that with more than one market the difficulty is for consignors to know where to send their goods, and for the buyers which market to visit for the purpose of buying, as it will be impossible to say at which of the two or more markets they will be likely to get the particular article they require.

However, I have two suggestions to make with reference to this objection. The first is, that in all large cities all the fish might be received at a dépôt, and distributed from thence to the other market or markets. And I take it the necessary conditions for the perfect working of this proposed system are:—

1st. That the dépôt should be served by all the railway systems possible, their lines running direct into it, and also that whenever water communication is possible, that the same should be utilised for the conveyance of fish direct from the sea to the dépôt. (The advantages of water carriage I have already fully set forth under the head of "Steam Carriers," and I do not therefore propose to take further notice of this subject.)

**Direct railway communication.**

2nd. That the dépôt shall be in direct railway communication with the market or markets in the different parts of the city.

3rd. That, as far as possible, fish coming by rail should be sent in separate trucks, according to its kind.

4th. That the dépôt shall be used exclusively as such (with ample cold storage rooms within its area), so that the business of despatching the fish with the greatest possible facility shall be uninterrupted, and the power of preserving the fish secured. Of course a fish market for the wholesale and retail sale of fish may be immediately adjacent to the dépôt.

Hours of business.

5th. The dépôt should be open at all hours for the reception and despatch of fish.

By this system consignors will always know where to send their fish.

The fish arriving at the dépôt in separate trucks, according to its kind, can be immediately despatched by means of the direct railway communication, and without unloading the trucks, to the particular market where its sale will be most probably secured.

The agents at the dépôt can serve their clients at the various markets, according to orders given from hour to hour, and at the conclusion of the day's business any fish remaining on hand can be run direct into the cold storage rooms on the railway trucks themselves, and preserved for use as required. By this means "gluts" and "short supplies" may be entirely obviated.

As a second alternative, I suggest the following, and while doing so call attention to the fact that the demand in towns and cities is almost entirely for fish of different kinds, for certain localities, and that in the "trade" the different kinds of fish are distinguished by the terms "prime" and "offal."

"Prime" and "offal" fish.

As the words convey, the "prime" fish is that eaten almost exclusively in the wealthier neighbourhoods, and the "offal" is that principally consumed in the poorer parts of a city.

My second suggestion, then, is that it might be possible, when there are two or more markets in a city, that the fish shall be sent in kind suitable for the locality of the market, that is to say, that there might be markets for the sale almost exclusively of "prime" fish, and others for "offal" fish.

By this system, also, consigners of fish from the coast 'll know to which market to send their various supplies.

and buyers will know where to obtain any particular kind of fish.

**London markets.**

Take, for instance, London, as being the largest city. It is quite assured, that should markets be established in the east, north, and south centres, that all the "offal" fish coming hither would find a ready sale, and the "prime" would be disposed of in the western districts.

Those living in the other districts named, who would be prepared to pay the price of "prime" fish, would hardly be worse served than at present.

**Fish brought to London.**

And it must be strongly represented that by far the greater proportion of trawl fish available comes under the head of "offal," as will be seen from the following figures. In the year 1881, Messrs. Hewitt, of Billingsgate, brought by their steam carriers to London 350,547 packages of "offal," against only 25,879 packages of "prime" fish, that is, fourteen times more "offal" than "prime."

**Wholesale price of fish.**

The average wholesale price realised was 5$\frac{1}{9}$ of a penny per lb. for the "prime," and only 1$\frac{1}{40}$ of a penny per lb. for the "offal" fish.

**Fish-supply poor man's question.**

It will therefore be seen that the fish-supply is principally a poor man's question, and I ask what has been done in the past to secure this immense supply to the poor at a rate bearing anything like a proper proportion to the wholesale price. Except for the noble efforts of the Baroness Burdett-Coutts in establishing Columbia Market, "nothing," and I believe that the reason of the failure of this market was principally due to the lack of direct water and railway communication, together with the want of sympathy and aid of the City authorities.* Undoubtedly the latter are not prepared to give any encouragement to undertakings in this direction, other than those emanating from their own body; instance their opposition to the Great Eastern Railway Fish Market, at Bishopsgate, which they will, if possible, cause to be closed. This market has many advantages, more especially the direct supply by railway.*

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* This market was re-opened in the autumn of 1883, under the *personal direction of* Mr. Burdett-Coutts.

Great Eastern Railway Market.

We pass on to point out that in many an existing market, the most desirable condition of its being in direct railway communication seems to have been overlooked. In London not a single line of railway runs into Billingsgate Market, or is even adjacent thereto; all the fish, save that which is water-borne, has to be carted from the various railway "termini" into the market, at a cost of about 5*s.* per ton.

Railway communication.

Billingsgate Market.

The inconvenience and loss arising from this, in any market, would be very serious, but at Billingsgate, situated as it is in the centre of narrow and crowded streets, it is incalculable.

It has proved, at times, positively impossible to get sufficiently near the market to unload the horse vans, and they have returned again and again, days in succession, until the contents have been condemned as unfit for food. The greatest inconvenience and loss have also been caused to the dealers by reason of this congestion of traffic.

Approaches to Market.

Whatever the number and position of markets, it is therefore equally important that the approaches by road should be ample in width and number.

Farringdon Market.

The new central fish market in Farringdon Street is certainly better situated than Billingsgate with reference to its communications by road and rail, but of course it is entirely cut off from direct water-carriage. The future success of this market seems quite problematic.

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* The Corporation hold that, under charter Edward III., 1326, they have the exclusive right of preventing the establishment of any market within a distance of seven miles of the city.

**Position of markets.**

It has apparently always been considered as perhaps the most important point in choosing the position for a fish market, that it should be a central one; and certainly where the town or city is only of a size sufficiently large to require one market, its position should be as central as possible; but in large cities, where two or more markets are necessary, I think the object should rather be to establish them on the outskirts; undoubtedly the sites would be less costly—a great consideration. We must bear in mind the natural tendency for our cities to extend in area; and provided the markets are, as they certainly should be, in direct railway communication with each other, and with the various railway systems, the distance they are apart is really immaterial. It has been objected that markets placed in a residential neighbourhood are very prejudicial to the vicinity, because of the disagreeable odour arising from the collection of fish in quantity; but it will be possible, I think, generally to find a suitable position. At any rate, the few must suffer for the benefit of the many, and if the market is properly constructed, and kept in a thoroughly sanitary condition, little inconvenience will arise.

In London one neighbourhood, viz., that of the parish of West Ham, the population has doubled in 10 years, and is now 120,000; the nearest fish market (Billingsgate) is situated about five miles distant. North London is equally badly served.

**Distribution of fish.**

With reference to the distribution of fish to the actual consumer, the question was asked of a practical man largely interested in the fish trade, what he considered was necessary for the success of a market. The answer was an unlimited number of hard-working costermongers. Another, a Billingsgate fish salesman, has stated that costermongers were his best customers, and that he had

**Costermongers.**

taken from £800 to £1000 cash in one morning from men of this class. It is estimated that 2000 costermongers now trade at Billingsgate, and the number is increasing; so we see how proper, and even necessary, it is, when designing a new market, that ample provision be made for the accommodation of such itinerant dealers.

Hitherto their wants and wishes seem to have been almost entirely overlooked; for instance, these men, if allowed, would do their own porterage at Billingsgate. Now they are put to considerable expense from being obliged to employ porters.

**Wholesale and retail price.**

The general public should be encouraged by every means to buy in the markets.

The difference between the wholesale and retail price is now enormous, the public and the fishermen being the sufferers.

**Construction of markets.**

We may hope, with "new and improved markets," that a change will take place in this particular.

As to the construction and internal arrangements of a fish market, it is of course important that the cost of same should be as low as possible, and nothing could be more suitable for the purpose than the general use of iron. With a span roof constructed of galvanized iron, avoiding the use of pillars inside the building, the structure would be light, airy, and inexpensive; special attention ought to be paid to the floors, which should be laid with concrete, and in such a manner that a thorough system of flushing easily and expeditiously may be daily practised.

**Underground cellars.**

Underground cellars are, in my opinion, objectionable, as they would interfere with the cleansing of the building, while the storage of fish underground would not facilitate its ready and easy manipulation in quantities.

The general shape of the building should be, as far as possible, rectangular, accessible to carts and barrows on all four sides. If situated at the water-side, nothing would be better than that the buildings should be ranged on the three sides of a rectangular wet dock, one end of course being used as the entrance to the dock; one side of each building (the water-side) could then be used for receiving the supplies from vessels, and the opposite sides for the delivery of fish into carts, &c. The inside of market should be reserved for the actual business of unloading and loading railway vans, and for the general manipulation in quantity of the fish coming by water and rail. Buyers would be served *from* the inside, they remaining altogether outside the market, a covered way being provided for them on the off side of the building, while samples of the fish to be sold would be exposed on open fronts. When a sale was effected, the fish would be passed through doorways opening out upon the covered way.

It is also essential that "cranes" and "overhead travellers" be provided for the unloading of vessels and trucks.

**Ice-house a**
**curing-hous**

An ice-house should be arranged within the precincts of the market, and covered standing space should be provided for carts and barrows, while, if space is available, houses for the salting, smoking, and general curing of fish should be arranged for.

## COLD STORAGE FOR FISH MARKETS.

Here we have an important detail to consider, and one that is rapidly coming into general appreciation. Undoubtedly in every fish market cold storage should be provided. When it it is considered how cheaply and efficiently the system of preservation by refrigeration can be used, we cannot but wonder at its tardy adoption.

Cost of co
storage.

According to the prospectus of a limited company issued within the last few weeks, it is estimated that meat, fish, &c., can be preserved in refrigerating houses, specially constructed for that purpose, at a cost of one-eighth of a penny per lb. per day, this rate leaving a large margin of profit.

And again, if it be possible to bring fresh meat, &c., from the Antipodes by this means, with profit, the cold storage of fish in markets for a day or two should be practicable.

The Manchester, Sheffield, and Lincolnshire Railway Company have cold storage for fish at Grimsby ;* and for the preservation of the fresh meat coming from America and Australia, the West India Dock Company, the London and St. Katharine Dock Company, the Mersey Dock Board, &c., have provided cold storage houses.

In a fish market I consider it would be wise to construct the cold storage rooms on a level with the main floor of the building, so that it would be possible to run the railway trucks, laden with fish, direct into the refrigerating house to be preserved till wanted. The length of time that fish may be thus kept fresh is really indefinite, but certainly it may be done for weeks. Of course I take it that upon the score of economy, the actual time during which the fish is in the refrigerating house would be limited as far as possible, but the fish could at least stand the cost of one or two days cold storage, taken at the rate we have mentioned.

It may be well to point out that the general adoption of refrigerating railway vans might, to a certain extent, do away with the necessity of cold storage rooms, as these vans would only require to be placed on a siding till the fish is wanted; but then the demurrage upon the vans must be taken into account. Probably, even should the fish be kept in the ordinary railway truck, in the refrigerating house, the cost would be less than by using the refrigerating van, for the double purpose of storage and preservation.

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* After making many inquiries, I cannot find that any other railway company, either in Great Britain or Ireland, provide cold storage for fish.

The market, as proposed, is of course a model market, a "new and improved market." How far it will be possible to build such depends upon the choice of locality and the available means.

## CONCLUSION.

In conclusion, I take the opportunity of expressing my thanks to those gentlemen who have so kindly placed at my disposal valuable papers bearing upon this important subject, Sir J. B. Monkton, Town Clerk of London, who has lent me the full report and evidence of the Fish Supply Committee of the Corporation of London, 1881, and Messrs. Dollman and Pritchard, solicitors, of 45, Cornhill, E.C., to whom I am indebted for the loan of various parliamentary papers, notably the full evidence taken before the Parliamentary Committee upon the Shadwell Market Bill. These papers were not procurable elsewhere.

The length at which I have written has greatly exceeded my original intention; but the difficulty has been to bring a subject so wide within smaller limits.

**Number of fishing vessels employed.**

The importance of the subject will be recognised on reference to the following table, taken from the report of the Sea Fishing Trade Committee, 1882, showing the number of vessels and boats registered under the Sea Fisheries Act, 1868, and of the men and boys comprising their crews, for the year 1881.

VESSELS AND BOATS.

| — | Of 15 tons, and upwards. | | Under 15 tons, Navigated by— | | Total. |
|---|---|---|---|---|---|
| | Number. | Tonnage. | Sails. | Oars only. | |
| England . . . . | 3,870 | 162,417 | 5,991 | 496 | 10,357 |
| Scotland . . . . | 3,765 | 66,285 | 8,570 | 1,810 | 14,145 |
| Isle of Man . . . | 318 | 7,628 | 132 | 9 | 459 |
| Channel Islands . . | 35 | 886 | 236 | 36 | 307 |
| | 7,988 | 237,216 | 14,929 | 2,351 | 25,268 |

The approximate number of men and boys employed in the above is given as follows :—

| | Constantly employed in Fishing. | Occasionally employed, other than regular Fishermen. | Total. | |
|---|---|---|---|---|
| | 56,089 | 38,675 | 94,764 | |

This does not include Ireland.

The following will also remind us how important a question to the community is that of the railway carriage of fish.

Total tons of fish carried by Railways.

*Total number of tons of Fish carried by Railways in the year* 1881.

| | | |
|---|---|---|
| England and Wales . . . . . . . | 206,381 | tons. |
| Scotland . . . . . . . . . . . | 59,259 | „ |
| Ireland . . . . . . . . . . . . | 7,312 | „ |
| Total . . . . . . | 272,952 | „ |

Regulation of the fishing industry.

It would appear that such an industry as this requires some fostering care and regulation, both as regards the mode of catching and the transmission and distribution of the fish. Perhaps it might be advantageously performed by a special Government department, with properly qualified inspectors, sufficient in number to allow of their making periodical visits to the various fishing centres. Their reports alone would be of great value.

**Railway rate**

The question of railway rates for fish cannot, I am afraid, be separated from the general one of railway rates and fares.

**Improved rai way vans.**

But possibly pressure might be brought to bear upon the various railway companies with reference to the kind of conveyance in which they transmit the fish, with a view to their introduction of refrigerating or other improved vans, or else the consigners of fish might themselves become proprietors of such vans.

**Steam fishin vessels.**

The possible use of steam vessels, for the catching and carriage of fish, should be earnestly considered by all associations which have for their ultimate aim the advancement of our fishing trade.

**Markets.**

Finally, the distribution of fish to the consumer, in a proper condition, can be greatly facilitated if the various market authorities will only grant every possible means for quick despatch and for the cold storage of the fish. In this latter direction I look for much being done towards the solution of the problem of the fish supply.

# APPENDIX.

## RAILWAY FISH RATES, 1883.

| From | To | Railway. | Miles. | Rate per Ton. (Not including delivery at Market.) | |
|---|---|---|---|---|---|
| | | | | "Prime." | "Offal." |
| | | | | s. d. | s. d. |
| Yarmouth . | London . | Gt. Eastern | 121 | 34 2 | 20 10 |
| " . | Norwich . | " | 20 | 10 0 | 9 2 |
| " . | Ipswich . | " | 44 | 20 0 | 18 4 |
| Grimsby .<br>Hull . | London . | Gt. Northern<br>Midland . | 175 | 30 0 | 25 0 |
| Inverness . | " . | L. & N. W. | 592 | 87 6 | 75 0 |
| Scarboro' . | " . | Gt. Northern | 234 | 55 0 | 42 6 |
| Plymouth . | " . | Gt. Western | 247 | 60 0 | 45 0 |
| Brighton . | " . | L. B. & S. C. | 51 | Mackerel and herrings.<br>21 6 | .. |
| Ramsgate . | " . | L. C. & D. | 86 | "Prime"<br>35 0 | 17 6 |

# A
# CENTRAL WHOLESALE FISH MARKET
# FOR LONDON.

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"*USUI CIVIUM DECORI URBIUM.*"—[CAYLEY AND BRIDGMAN.]

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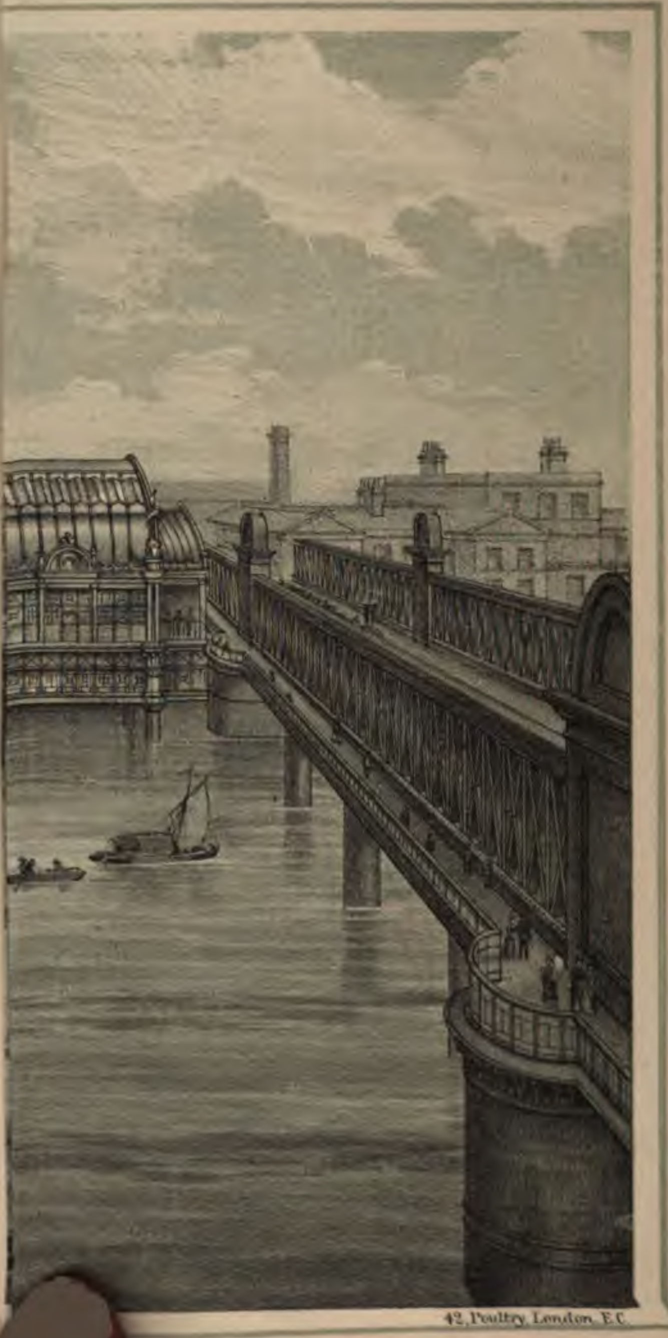
*Plate I.*



42, Poultry, London, E.C.

# A CENTRAL
# WHOLESALE FISH MARKET FOR LONDON.

## PART I.

### GENERAL—GEOGRAPHICAL.

THE supply of so important an article of food as fish to the population of London and its near surroundings, amounting to about 8,000,000 of people, may well be regarded as a great national question. Moreover, it can scarcely be considered a single and simple question, but rather a compound problem of many parts, each of which requires distinct research and treatment.

This compound problem is brought prominently before public notice at the present time, and "The International Fisheries Exhibition, under State Recognition," may be regarded as the effort of the nation, through its Executive, to arrive at a satisfactory solution of it.

> NOTE.—The generally accepted rule that demand and supply are best let alone to find their own way to each other seems to present a strong objection to this effort, but there may reasonably be cases in which the State may usefully undertake such a task, or at least assist in performing it, by its large command of means for collecting and disseminating information, and by the use of its authority in

> clearing away obstacles; in fact by taking care that demand and supply *are* let alone, and that no avoidable or removable impediments, whether arising from ignorance or any other cause, shall stand in their way to each other.

This, it seems, is what the Government proposes to do. In this essay we shall endeavour to assist in some degree—and in practical form—in one department of this enquiry.

The first natural and general division of this problem is, of course, into three parts:

1. The Demand.
2. The Supply.
3. The Conveyance.

And the questions these suggest for elaboration and sub-division are:

1. What does the population want from the seas?
2. What do the seas provide for the population?
3. What machinery of conveyance from one to the other will be most effective?

We do not propose to enter here upon the first and second questions any further than to say that the best theoretical authorities agree that, large as the excess of demand over supply now is, there is yet a greater excess which is latent; and that the supply in the waters around Great Britain is, or at any rate might be made, by a better understanding of the natural history of fishes, and some consequent regulations and artificial help, all-sufficient, and we shall quote some opinions given in evidence by practical men in support of these positions, not forgetting, however, that the Government is collecting for the nation an immense amount of information with regard to additional supply from all possible sources.

With these preliminaries we pass at once to that particular sub-division of the third question to which we invite attention, namely, the precise point at which supply and demand can meet, at the least practicable expenditure of time, money, and labour, and with a maximum of advantage to each.

Let us see what it is we have to consider. There have recently been three important movements in connection with the subject of fish supply to the metropolis.

Firstly.—"Evidence taken on an enquiry into the destruction of fish at Billingsgate, in consequence of the alleged inadequacy of the accommodation at the market, before Spencer Walpole, Esq., Inspector of Fisheries, by direction of Secretary Sir William Vernon Harcourt, M.P., on the 14th and 15th of December, 1880."

Secondly.—A report published in Blue Books by the Corporation of the City of London entitled "Fish Supply to the Metropolis—Minutes of Proceedings before a Ward Committee of the Court of Common Council—W. H. Pannell, Esq., in the chair," which proceedings commenced on July 5th, 1881, lasted fourteen days, and embraced an immense amount of valuable information from practical men in every branch of the fish trade.

Thirdly.—"The International Fisheries Exhibition," by which still more extended information will, as we have said, be collected and disseminated.

It is a fair presumption that, as a result of these three important movements, the demand which we have called latent will be aroused, and the supply amply provided; and the third question then naturally steps in, "How can these two be brought together with a maximum of advantage to each?"

This question again subdivides itself into the depart-

The question: "MARKET."

ments of "Conveyance *to* London, and market accommodation *in* London." The former, we have reason to think, is receiving exhaustive consideration elsewhere, and we come direct to the latter, upon which we propose to offer some suggestions.

London should hold first place.

We shall not dwell unnecessarily upon the present lamentable state of things in this respect. It is admitted on all hands, and the press is active in exposition of the fact, that the deficiencies of Billingsgate and its surroundings are a great scandal to London, and that a remedy cannot be adopted too soon. We may even be pardoned for hinting that, notwithstanding the powerful interests which Billingsgate commands, yet the increased facilities afforded by railways for the more equal transmission of fish throughout the country seem to render it the first and most imperative interest of the London fish merchants to keep a very jealous watch upon the inducements which London offers to the catchers and senders, and to take care that in market accommodation, however many rivals they may have, the utmost resources of science and enterprise shall be combined to retain for the metropolis the first place.

It is plain this matter is urgent because, let demand and supply increase as they may, they cannot benefit each other without adequate means in this respect. But although in the admissions and statements alluded to the writers represent the feeling both of the public and of the greater part of the trade, yet there is a remarkable lack of suggestions for radical and comprehensive improvement. We shall therefore offer no excuse for confining our remarks in this essay to one point, namely, the setting forth what presents itself to our minds as a thorough remedy.

**Remedy for present evils.**

The first point seems to be,—

Should there be one market or more?

The opinions of important witnesses were not unanimous upon this point, but perhaps the following clause, extracted from the "Report to the Court of Common Council from the Fish Supply Committee, August, 1881," may be taken to embody the impression conveyed by those opinions.

"The whole of the information has received our closest attention, and we have now the satisfaction of reporting that we have unanimously, though, as regards some members, not without altering a previous impression, arrived at the conclusion that, in our opinion, one wholesale market is calculated to meet the requirements of the trade and the interests of the public."

Undoubtedly the advantages of ONE CENTRAL WHOLESALE MARKET are great, and we are inclined to think that from the time this opinion was recorded till now there has not been any information before the public at all calculated to shake this conclusion.

Whatever may appear desirable as to additional retail or subsidiary markets, it does seem clear, that, with respect to an article the supply of which must vary from day to day, in order to secure to the trade and the public all possible advantages, the day's supply should be collected into one place first.

With respect to additional retail markets the Committee say, "We at the present time offer no opinion," and we follow their example in order to avoid drifting from our subject.

**Market site requirements.**

Let us consider, then, what are the conditions to be borne in mind in the

SELECTION OF A SITE FOR
A CENTRAL WHOLESALE FISH MARKET FOR LONDON.

We take the *essential* conditions to be FIVE:—

1.—CENTRAL POSITION.
2.—SUFFICIENT AREA.
3.—WATER COMMUNICATION.
4.—RAILWAYS RUNNING THROUGH.
5.—ROADS TO AND FROM IN ALL DIRECTIONS.

1. *Central Position.*—Not necessarily in the centre of habitations, indeed, if practicable, this should be avoided, but certainly in the centre of communications.

2. *Sufficient Area.*—This is a very comprehensive head, and must be taken to mean:—

Room, not only for the easy reception of the utmost probable supply as soon as it arrives, but also convenience for exhibiting it in such a manner that buyers can get a complete view of it in the shortest possible time; also

Room for its quick removal; also

Room for a large number of stalls so that dealers of limited means may secure their fair share of accommodation; also

Room for all vehicles, whether railway trucks, vans, carts, barrows or any other used both in bringing into and taking from the market, so that all may be in the market area, under cover, and in no case required to stand in the streets; also

Room and appliances for storing and preserving fish in ice or refrigerated storehouses when necessary from its arrival out of market hours; also

Room for curing fish, so that those engaged in that trade may rent on easy terms all necessary convenience for that process, instead of, as now, having to remove the fish from the market to the suburbs, cure it there and bring it back to market again; also

Room for salt-water tanks, if deemed necessary, to receive fish sent alive to market, as it is intimated in evidence is done in America; also

Room to carry out the recommendation of the Fish Supply Committee in this clause—"Of the market itself we are of opinion that it should be one based upon the same system as is at present in existence in Paris, viz. a wholesale, a semi-wholesale and a retail market all under one roof;" also

Room, be it remembered, for all the operations incidental to the wholesale, and nearly all those incidental to the semi-wholesale, markets to be carried out with ease in a few hours each day; and lastly,

Room for the utmost probable number of the public who may visit the retail market to purchase.

3. *Water Communication.*—This has been, perhaps, the most warmly disputed point, but we are inclined to think that neither its detractors nor its supporters have done justice to its value or even to its necessity. The chief reason urged in its favour has been that vessels bringing fish should be able to unload at the market. Certainly the owners or captains of such vessels have some claim to a choice of doing so if they please, but we can scarcely imagine the custom being continued, for reasons which we shall give in place, unless indeed in the case of fish brought to market alive.

But there are two grounds for arguments in favour of a water-side market which seem to have had little or no consideration, but which appear to us far more weighty than merely the delivery of fish from the ship's side. These are—

*Ventilation and Sanitary Wholesomeness.*—These, we submit, are the really powerful reasons for a river-side site. The Thames furnishes the largest open space in the metropolis, and the best obtainable ventilation is to be got there; and the refuse, which must be large, can be run from the market floor into barges, and removed clear away; indeed, one witness considered it would be almost impossible to keep a large inland market sweet.

4. *Railway Communication.*—There should be rails *upon the floor* of the market in communication with the general system of railways, so that trucks can be run in loaded as they arrive, and their contents seen and dealt with as soon as possible. Each truck should in fact become, *pro tem.*, a wholesale shop. There should also be passenger stations either in or contiguous to the market and on lines in connection with the metropolitan system.

5. *Roads* (*obvious*).

Conclusion from acceptance of conditions.

These FIVE appear to be the essential conditions; whatever additional advantages can be obtained would be a clear gain, but it does not appear that the acquisition of any other could compensate for the loss of any one of these, and we think that *no spot which does not offer these conditions complete should be accepted as a chosen site so long as it can be shown that any spot can be found in which they are all in combination.* If this rule be accepted, it will be seen at once how large a step is taken towards a solution of this much vexed and otherwise difficult question.

Let us see to what conclusion it leads.

Take a map of London and it will be seen that, roughly speaking, the river forms a broad divisional line running nearly through the centre of the map from east, westerly as far as Charing Cross. Take, say, the central mile, or at most a mile and a half of that river, and the banks of that central portion seem to present all the scope which, according to the accepted rule, the search for a site can take. Consider again the necessity for railway and river to meet, and the choice becomes still more limited.

Now take the conformation of the river into account. We have said that from the centre of the east side of the map, the river proceeds westerly as far as Charing Cross. At that point it makes a rather sharp bend toward south-west. The tidal force, which is fairly great, naturally drives the water toward the outer edge of this bend, and the result has been a gradual silting up of mud on the inner edge until it has formed a kind of promontory there; and we think it will at once be obvious that this is the one spot of which it may be said that *nature* has prepared it for the very purpose for which we shall now point it out. Geographically and physically, it is the natural centre of London, and art, however unconsciously, seems to have recognised this by the fact that the metropolis has been gradually clustered round it, and as far as practicable all principal roads and means of communication are made to lead to and from it.—(SEE KEY PLAN, facing p. 507.)

## PART II.

### PRACTICAL.

In this Part a Scheme is proposed in accordance with the views propounded in PART I.

The merits upon which the claims of this scheme rest are :—

CENTRAL POSITION.
RIVER FRONTAGE.
RAILWAY COMMUNICATION (on the floor).
PASSENGER STATIONS.
AMPLE APPROACHES.
ADEQUATE AREA.
COMPLETE INTERNAL ARRANGEMENTS.
GENERAL ECONOMY.
METROPOLITAN ORNAMENT, and
UTILISATION OF WASTE SPACE.

### PRELIMINARY.

In a Blue Book containing " Evidence taken on an enquiry into the destruction of fish at Billingsgate in consequence of the alleged inadequacy of the accommodation at the market, before Spencer Walpole, Esq., Inspector of Fisheries, by direction of Secretary Sir William Vernon Harcourt, M.P., on the 14th and 15th December, 1880," Mr. Scott, in explaining some plans for the construction of better approaches to Billingsgate, which he has handed in to the inspector, says: " Then you will find here plan ' A ' could be constructed for the sum of £88,000 ; that the widening of Lower Thames Street would cost £300,000 ; that the new street from Eastcheap would cost £102,000. . .

Now in the year 1874 is another set of plans proposed by the Improvement Committee of the City of London. This is a new street that has now been proposed, and it is the street that the present architect, Mr. Jones, with the concurrence of this Committee, has recommended the Corporation to carry out, though unfortunately the amount of the cost is so enormous that it is impracticable."

Now keeping in mind this official and important statement, let us suppose some such plan as is here indicated to be accepted, what would all this expenditure be intended to accomplish? Simply to open up streets broader than those now in use for the passage of vans laden with fish for Billingsgate Market—an object very good in itself, no doubt. But supposing such accepted plan to be worked out, and supposing—which is doubted by more than one witness in the course of the enquiry—the results proved to be all that was expected, what then? Would the whole machinery for supplying the public of London with fish be such as that public would be or ought to be content with? We submit not. The entire system of fish supply and distribution, of which Billingsgate may be considered the pivot, would still remain, as it is now, as far as the internal arrangements for London are concerned, a part and parcel of an age gone by—probably adequate to the requirements of fifty years ago, but strangely out of keeping with the present time. London has, in that period, by the invention of railways, emerged clear out of an old state of things and advanced into a new, and Billingsgate has not moved in the same ratio. But it is quite time now that London made haste to take up its proper place among cities in the matter of a Fish Market. This is what the public is demanding—and will certainly have.

## SCHEME.

### PREAMBLE—REQUIREMENTS.

Now, in the first place, what are the requirements which a food-market system intended for the supply of a large community should meet? We will take them to be three, and the more quickly perishable the commodity the more imperative the conditions become. Put shortly they are:—

Means for,—1st. RAPID AND COMPLETE COLLECTION.
2nd. RAPID TRADING.
3rd. RAPID AND COMPLETE DISTRIBUTION.

By "*rapid and complete collection*" is meant — the market should be so situated that the supply from every producing point can be sent into it direct, and in the shortest possible space of time.

By "*rapid trading*" is meant — the market should be large enough to receive the whole day's supply as soon as it arrives, and, moreover, large enough to afford every facility and convenience for all sellers and buyers requiring its use.

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### *Extracts from Evidence.*

Throughout this PART II. we shall introduce "Extracts from Evidence" contained in the Reports of official enquiries named in Part I., *ante*, p. 473. Their bearing upon the "Scheme" set forth in this "Practical" part will be readily seen.

Mr. William Birt, Great Eastern Railway, Ev. W. H Pannell, p. 367: "There is no doubt, I think, that the convenience of London, and more especially the poor of London, calls very loudly for more to be done in the way of fish accommodation."

### SCHEME.

By "*rapid and complete distribution*" is meant—the market should be so situated as to render available all possible means for distributing the commodity to every part of the community dependent upon it for supply, and that as quickly and as nearly equally to all as practicable, and no portion or class of the public should have undue or avoidable preference to the prejudice of any other portion.

These are the three necessary conditions. No one or two of them will be sufficient, and no one or two should be over considered to the damage of the remainder; it must be all three, and nothing less than all three in the highest attainable degree of development, and, moreover, all three in balance with each other, ought to be endured.

There is no need to insist further upon these premises; they are, of course, no invention; they are transparent, and

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### *Extracts from Evidence.*

Mr. Robert Mellish, Grimsby Docks, Ev. W. H. Pannell, p. 14: "Manchester is half a century ahead of London in the fish matter."

Mr. Robert Mellish, Grimsby Docks, Ev. W. H. Pannell, p. 8: "I believe if there were a central market, so that poor people could buy it, they would get cheaper fish. I think there would be 25 per cent. more fish come. Hundreds of tons come to Grimsby and go out abroad. There is some splendid cod-fish at Grimsby sold at £6 and £7 a ton, whereas if it came to London a man could sell it at 2*d.* per lb. *if he had a place.*"

[NOTE.—2*d.* per lb. is £18 13*s.* 4*d.* per ton.]

SCHEME.

will doubtless be accepted and pass unchallenged as a test which any system either existent or proposed may fairly be required to bear.

Naturally, then, the question arises—" Does Billingsgate bear this test, or would any practicable amount of opening up streets to it enable it to do so?" We think not. The whole burden of the evidence seems to show that, on the contrary, it would still remain as it now is, a most astonishing failure in all three points. It may fairly be presumed, then, that such a scheme is a thing desired, and, if brought forward, no matter by whom, it will be worthy of all consideration.

We come now to our

"SCHEME FOR A CENTRAL MARKET,"

a plan of which is submitted herewith, and we propose to show that its adaptability to all the suggested requirements is singularly remarkable and complete.—(See PLAN, opposite p. 490.)

Locality on waste space

Between Waterloo Bridge and Charing Cross Railway Bridge, on the south side of the river, there is, at low water, a bank of mud stretching out (according to the Ordnance map) to an average of 320 feet from the shore. Upon that bank it is proposed to erect a structure for the fish market, the front elevation of which, facing the river, would start from the second pier of Waterloo Bridge from the Surrey shore, and taking a curved line,

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*Extracts from Evidence.*

Mr. Robert Mellish, Grimsby Docks, Ev. W. H. Pannell, p. 14: "Our market (Grimsby) is over a quarter of a mile long, and it is covered in."

### SCHEME.

nearly corresponding with and about 30 feet within the edge of the mud at low water, would be carried clear above the water on columns and girders to, and finish at, the Surrey side pier of Charing Cross Railway Bridge. This frontage line would thus follow the natural curve of the river at this point, and would, roughly speaking, be parallel with the Thames Embankment on the opposite shore.

The back elevation would be distant from the wharves and business premises forming the Surrey shore, 60 feet at one end and 100 feet at the other end, and therefore would leave a width of 225 feet for the market. The principal floor of the market would occupy the entire space of this width from the one bridge to the other, at a level of about 50 feet above "Trinity high water-mark," and corresponding exactly with that of the roadways of Waterloo Bridge and Charing Cross Railway Bridge. The principal market floor would have a frontage of 940 feet, a width of 225 feet and an area of 191,250 square

**Clear away from the shore.**

**Dimensions.**

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### *Extracts from Evidence.*

Mr. J. P. Knight, London, Brighton and South Coast Railway, Ev. W. H. Pannell, p. 550: "Having regard to the extension of London westward, I have no doubt ultimately that if you commence with one (market) you will be obliged to have another. It must be a very great inconvenience now to many of the retail dealers to send their carts such great distances as they do. Take such districts as Bayswater, Hammersmith, Pimlico, and all outlying places at the west, it must be a very serious inconvenience to them."

## SCHEME.

**Eight times the area of Billingsgate.** feet, or 4⅜ acres. This is more than eight times the are of Billingsgate Market, and is within 5 per cent. of tha of the whole cluster of markets at Smithfield adde together, including the poultry market now being erected.

The east end of this floor would join, and be quite ope to, the roadway of Waterloo Bridge, and being, as sai above, on the same level, each would be simply a continuation of the other. The superstructure or coverin of the market would be set back from each of th

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### *Extracts from Evidence.*

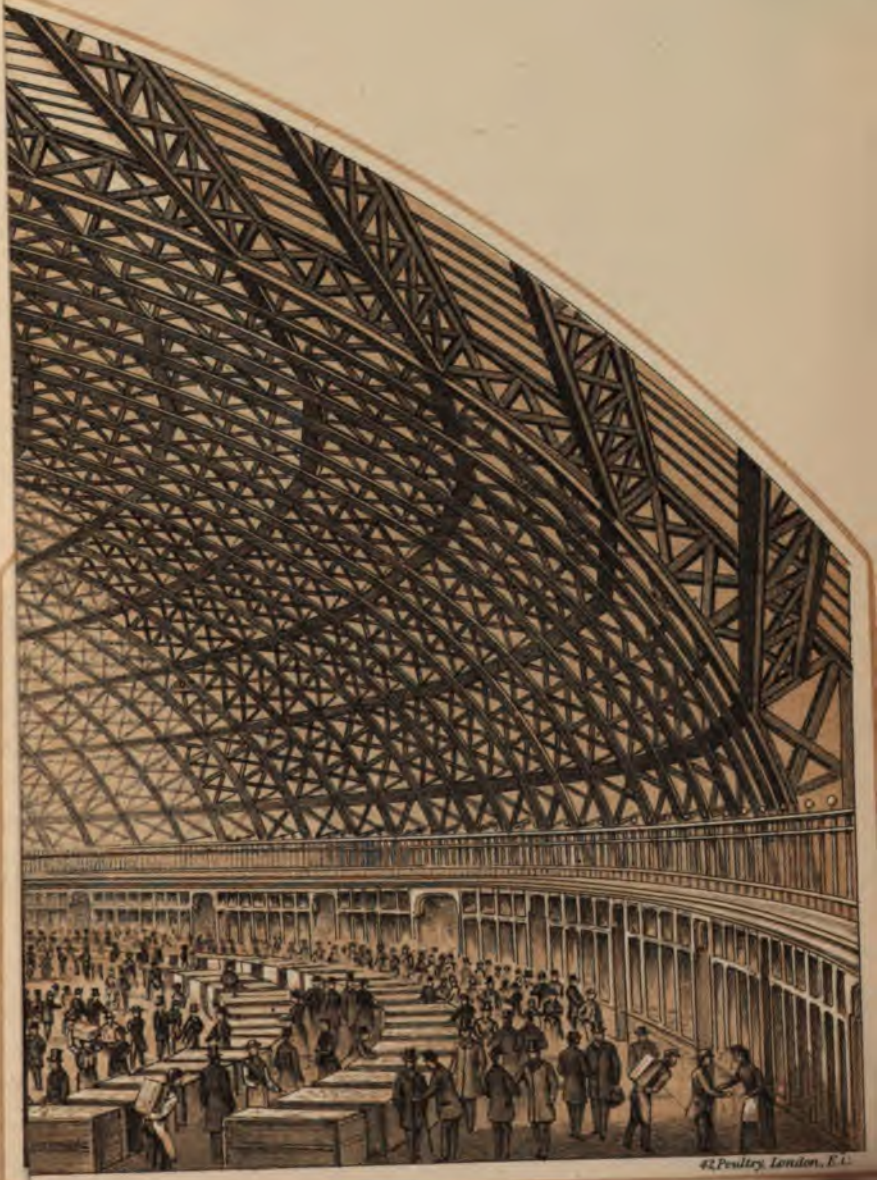
Mr. Henry Oakley, Great Northern Railway, Ev. W. H Pannell, p. 271 : "I should endeavour to make the grandes market I could, giving freedom of access and great facilit for unloading."

Mr. Alderman Smethurst, Grimsby, Ev. W. H. Pannel p. 337 : "*Q.* Do you think that Billingsgate is large enoug for the trade?—*A.* Not one-fourth."

Mr. Paul Storr, Market Clerk, Billingsgate, Ev. W. H Pannell, p. 647 : "*Q.* Have you any idea what the rive frontage of Billingsgate is?—*A.* Yes, it is about 16 feet."

Mr. James Blackie, Leith, Ev. W. H. Pannell, p. 191 "*Q.* Have you ever thought of how fish could b supplied in the metropolis cheaper than it is now?—*A.* . . . The better plan in my opinion would be to have a larg market within a reasonable distance of the principal rai ways that bring fish; to have a large open market wher people can go in and get what they want. That is not s in Billingsgate. You cannot do it. There is no room."

*Plate II.*



*42, Poultry, London, E.C.*

bridges some 30 feet, in order to facilitate ingress and egress at these points without interrupting the ordinary traffic of the bridges.

There would also be a sub-floor at a level of about 25 feet below the principal floor, and therefore about 25 feet above high water-mark—thus permitting boats and barges to pass underneath; and this floor would afford additional space of upwards of 4 acres for purchasers' carts and other vehicles. There would also be some accessory spaces, as shown on plan, and with these the available area would be 10⅓ acres.

Gross area over ten acres.

The structure itself would be erected upon three rows (longitudinally) of iron columns rising out of the water.

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*Extracts from Evidence.*

Mr. Samuel Ives, Billingsgate, Ev. W. H. Pannell, p. 452: "After considering this matter in all its bearings and making allowance of space for salesmen and other dealers, space for receiving the fish . . . . and space for the numerous vehicles of customers coming to the market, an area of at least 7 or 8 acres ought to be provided. It matters not in my opinion whether it is situated in Lower Thames Street or elsewhere so long as we obtain the space required."

Mr. Thomas Rudkin, Ev. Spencer Walpole, p. 97: "*Q.* By the Inspector: What is the acreage of Billingsgate market? Some one said it was an acre and a half, but I cannot make it out by figures.—*A.* I cannot tell you exactly what it is.

"*Q.* 22,000 square feet is nothing like an acre?—*A.* It is nothing like half an acre."

## SCHEME.

Those of the front row would be about 100 feet apart, as shown on plan. The whole of the columns would pass up through and support the sub-floor, and would also carry the principal floor. The entire space of the principal floor would be covered in one span by a structure chiefly of iron and glass, in a style somewhat similar to the roof of the Midland Railway Terminus.

**Non-interference locally.** It will be seen that such a structure as is proposed would in no way interfere, firstly, with the current of the river; secondly, with the local traffic of barges and boats; or thirdly, with the general navigation of the river, ***inasmuch as the "centre of channel at low water," as indicated on the Ordnance map, is equidistant from the front of the proposed market and the Thames Embankment on the opposite side of the river.***—(Shown also on PLAN, opposite p. 490.)

Moreover, the clear width of river surface between the Thames Embankment and the river front of the market would be about the same as the entire width of the river at Billingsgate.

| | Feet. |
|---|---|
| Length of Waterloo Bridge . . . . . . . . | 1326 |
| Deduct Embankment, say 120 ft. | |
| ,, Market ,, 300 ft. | |
| ——— . . . . . . . | 420 |
| | 906 |
| Length of London Bridge . . . . . . . . | 915 |

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*Extracts from Evidence.*

Mr. T. Brown, Lowestoft, Ev. W. H. Pannell, p. 293: "It wants a market 5 times as large. *Q.* Would that be to your benefit as a sender?—*A.* Yes, and to the public at large—I am certain of it."

## SCHEME.

A very important fact is, that 91 per cent. of the general navigation of the river passes underneath the four arches comprised by the north half of Waterloo Bridge, leaving the 4 arches of the south half practically unused. In confirmation of this an analytical table of traffic is here given.

Table showing the traffic through each of the arches of Waterloo Bridge during 12 hours (from 8 A.M. to 8 P.M.) on Tuesday, August 9th, 1881. The arches over the water are 8 in number. They are represented as seen from a point west of the bridge, and the numerating commences at the north or Thames Embankment end :—

| Thames Embankment. | Arches. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Steamboats . . . . . . | 125 | 43 | 6 | 9 | 4 | 1 | 0 | 0 |
| Tugs and barges . . . . | 0 | 10 | 39 | 68 | 12 | 3 | 0 | 0 |
| Oar barges . . . . . . | 2 | 19 | 60 | 27 | 4 | 2 | 0 | 0 |
| Sailing barges . . . . | 0 | 1 | 9 | 4 | 4 | 0 | 0 | 0 |
| Wherries . . . . . . . | 0 | 3 | 1 | 1 | 1 | 0 | 0 | 0 |
| Small boats . . . . . . | 0 | 2 | 7 | 14 | 10 | 2 | 4 | 0 |
| Police boats . . . . . . | 3 | 2 | 2 | 0 | 1 | 1 | 0 | 0 |
| Torpedo boat . . . . | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Sailing boats . . . . . | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| Totals | 130 | 80 | 124 | 128 | 36 | 9 | 4 | 0 |

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### *Extracts from Evidence.*

Mr. Robert Mellish, Grimsby, Ev. W. H. Pannell, p. 14 : "I have had really good fish sent to London, and it has been forwarded to Liverpool because there was no room to sell it in London."

## SCHEME.

Utilisation of waste space.

An incidental, but immensely great merit in this selection of a site may here be mentioned, namely, the utilisation in one of the most valuable positions in London of a large space which is now entirely useless, by erecting upon that space a building which, in addition to being an immense boon as a convenient central market, would form also a very handsome ornament to the metropolis, and that without any displacement of property or interference with existing rights, commerce, industry, or convenience.

It has now to be shown how the proposed scheme would fulfil the requirements set forth in the preamble as a fair test.

### REQUIREMENTS—HOW MET.

### *Firstly: As to Rapid and Complete Collection.*

Railways on the floor.

Upon the floor of the market in the plan will be seen lines of rails in metal communication with all the fish-bringing railways. By this is meant that trucks which are sent to London with fish from any and all the ports of Great Britain could, without any addition to the existing railway system, except the actual approach to the market

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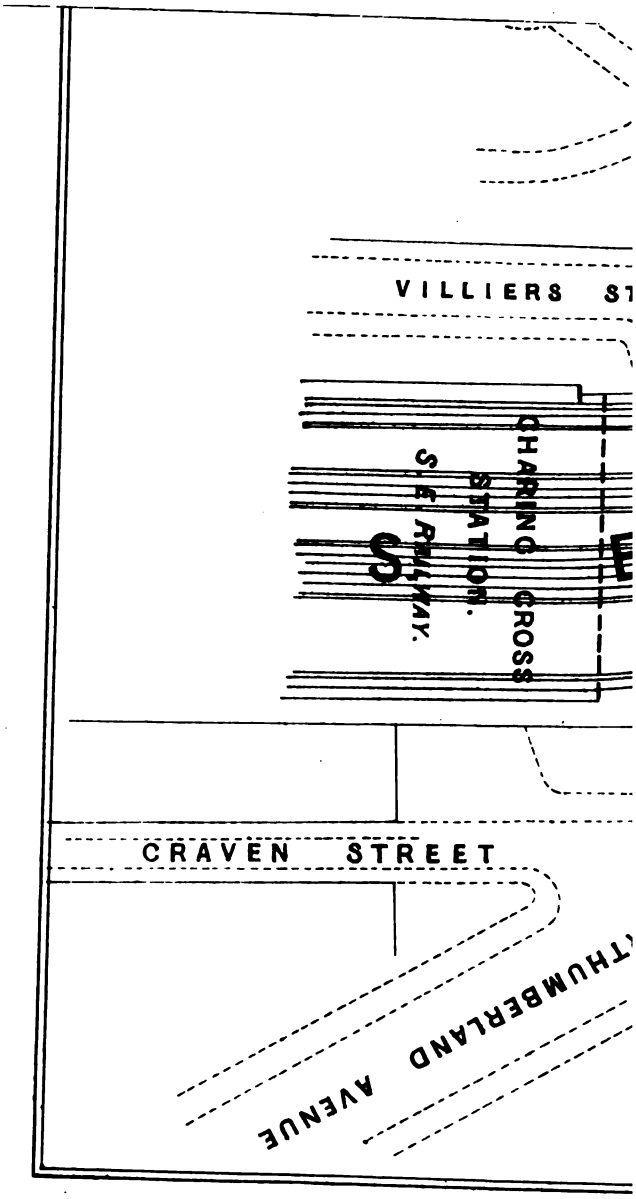
*Extracts from Evidence.*

Mr. Thomas Rudkin, Ev. S. W., p. 92: "*Q.* Then what is your remedy for the present ills?—*A.* My remedy is the entire and absolute removal of the market.

"*Q.* Where are you going to remove it to?—*A.* Any site in immediate contiguity with the river, where there are ample and sufficient approaches for the railway waggons to get to and from."


VILLIERS ST
CHARING CROSS
STATION.
S.E. RAILWAY.
S
CRAVEN STREET
THUMBERLAND AVENUE

SCHEME.

th-Eastern Railway, and junctions between
stern, South-Western, and London, Chatham
ailways at Waterloo and Blackfriars—more
under the head of Distribution—run right
r of the market without the fish being un-
any way shifted or interfered with from the
cked at the sending port, and the fish would
market from two to eight hours earlier than
course would be so much the better in
he result of shorter time and no knocking
t.

**Advantages to rail-borne fish.**

which this could be done is shown thus.

report is current that a Bill may probably be
into Parliament in the next Session for

*Extracts from Evidence.*

nbert, Great Western Railway, Ev. W. H.
: " *Q.* With reference to the last question it
junction for all the lines of railway to
place for the simple purpose of bringing
*A.* It would involve a communication with
olitan Railways, and it would involve also
tion under (?) one particular market, which
estion requiring very careful consideration
expense.

ting to many millions of money ?—*A.* I would
r an opinion upon that." [This scheme
ll the railways *into* the market, that is, not
r overhead, *but on the floor*, for almost no
ratively.]

SCHEME.

powers to enlarge the Charing Cross Station of the South-Eastern line, and widen the bridge thereto, for the purpose of making Charing Cross a terminus for the Great Western, the Midland, and probably others of the north lines of railway. If this be done, the manner in which the trucks would arrive at market would require no explanation, but if not, the method is shown in the following manner.]

N.B.—Such a Bill has now passed.

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### *Extracts from Evidence.*

Mr. Henry Oakley, Great Northern Railway, Ev. W. H. Pannell, p. 268: "We allow 3½ hours for every van to unload. I do not desire to exaggerate, but our vans are very frequently detained there from 6 or 7 hours, and occasionally 10 hours. Our fish comes in at a quarter past 3 in the morning. We send it down to the market at a quarter past 4."

Mr. Thos. W. Downing, Yarmouth, Ev. W. H. Pannell, p. 146: "*Q.* In your experience is it difficult to get your fish into Billingsgate Market?—*A.* I often receive telegrams at 11 or 12 o'clock—'Your fish not arrived yet; Thames Street entirely blocked.' . . . . When they say, your fish has not arrived, that means something like 1*s.* 6*d.* or 2*s.* less for your herrings, and that makes a lot of difference if you have 400 or 500 pads."

Mr. J. Sims, Hull, Ev. W. H. Pannell, p. 29: "I have paid this rate on purpose to secure the fish in proper time, and I never could get anything out of it because the very first lot I paid for, instead of being delivered at 5 o'clock, it was delivered at 11 o'clock."

## SCHEME.

The market being practically upon the South-Eastern Railway, it is only necessary to show how all the fish-bringing railways run on to the South-Eastern. Taking the trunk lines which by their branches collect the fish and bring it to London, we find that the principal of them not only *can run* on to the South-Eastern, but they can easily have the choice of two ways of doing so. Taking them in the order in which they are placed in the "Evidence before Spencer Walpole, Esq.," page 13, we have:

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### *Extracts from Evidence.*

Mr. G. Fellows, Great Grimsby, Ev. W. H. Pannell, p. 248: "London gets its share, not so much as it might get. I have seen fish stand . . . . till 10 or 11 o'clock in the morning, in the railway waggons, and not landed in the market at all. Of course that must open my eyes that I was at a very great disadvantage in sending my fish to London."

Mr. M. Harris, London, Chatham and Dover Railway, Ev. W. H. Pannell, p. 320: "If you can remove traffic from the streets by taking the stuff into the markets by railway waggons, you will do a great deal; but I do not see how you can do that at Billingsgate. It would be very hard to make a railway access from all the metropolitan companies into that market, and I very much question if any of them would face the cost of doing it. I think that is out of the question."

[NOTE.—In this scheme it is practically already done.]

Mr. Thomas W. Downing, Yarmouth, Ev. W. H. Pannell, p. 147: "*Q.* If the fish arrives late, the London market would be deprived of the supply, and it would be forwarded to the country?—*A.* Yes, it is repeatedly done."

## SCHEME.

Great Western runs on at Reading to South-Eastern

The fish collected in broad gauge trucks below Exeter could be changed at Exeter as other luggage is when necessary.

Also, fish brought to Paddington in broad gauge trucks could be shifted to narrow, and sent by Metropolitan to . . . South-Eastern

Also, wherever G. W. runs on to S. W., as at Basingstoke or Salisbury, fish could be sent by S. W. and by Waterloo Junction to . . . . . . . . . . . . . . . . . South-Eastern

Great Northern, by Metropolitan, L. C. & D. R. and Southwark Junction to . . . South-Eastern

Also by Clapham Junction to S. W. R. and . . . . . . . . . . . . . . . South-Eastern

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### *Extracts from Evidence.*

M. C. Pennell, late Government Inspector of Fisheries, Ev. W. H. Pannell, p. 613: "Of course, if these markets were established in connection with the great trunk lines conveying the fish from the different ports of the kingdom, a very large supply could be obtained, and I should think they could be supplied at about half the present price, and still bring a very large profit to everybody."

Mr. Edward Charles Moore, Waterford, Ev. W. H. Pannell, p. 131: "*Q.* Are you satisfied that it (Billingsgate) is proper to meet the requirements?—*A.* Not at all between the purchaser and producer . . . . There ought to be a free market entirely, open all day long, and it ought to be in a central position where all railways can have access to it."

### SCHEME.

| | |
|---|---|
| Great Eastern, by tunnel line to New Cross Junction with | South-Eastern |
| South-Eastern | South-Eastern |
| London, Chatham and Dover, by Southwark Junction to | South-Eastern |
| London and North Western, by Willesden, thence by Metropolitan on to | South-Eastern |
| Also by Clapham Junction and S. W. to | South-Eastern |
| London and South-Western, by Waterloo Junction to | South-Eastern |
| London, Brighton and South Coast to | South-Eastern |
| Midland, by Metropolitan to | South-Eastern |
| Also by Clapham Junction and S. W. to | South-Eastern |

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### *Extracts from Evidence.*

Mr. J. Mitchell, Whitby, Ev. W. H. Pannell, p. 120: "*Q.* How long does it take you to bring your goods up from Whitby?—*A.* Sometimes 12 hours.

"*Q.* And it takes sometimes 4 hours to get through? —*A.* There are many times the goods do not get to No. 7 (Thames Street) before 10 o'clock in the morning.

"*Q.* And you ought to have them at what time?—*A.* 7 o'clock.

"*Q.* That would be almost losing the market.—*A.* It is a deduction of 20 per cent. from my goods."

Mr. D. Stevenson, London and North-Western Railway, Ev. W. H. Pannell, p. 286: "*Q.* Meat from Liverpool gets to Smithfield without the slightest difficulty?—*A.* Yes.

"*Q.* But fish from Holyhead by train gets to Billingsgate with the greatest possible difficulty?—*A.* Exactly so."

## SCHEME.

This comprises the round of fish-bringing railways, as shown also in the report of the "Fish Supply Committee" of August 9th, 1881, page 11. It also assumes the formation of the two junctions before named as shown in plan.

The spot fast becoming the centre of railway system.

But supposing that all this cannot be accomplished *at present* it still seems to be only a part of the natural course of things that such a market *should and must* at some time or other be supplied by railways running on to its floor. It also seems in the natural course of things that all railways running into London should at some time or other convey to one central station, and that such station should be at Charing Cross. These are very strong reasons why it is therefore better that the market should be at once placed where it will be for all practical purposes a part of such central station—while the river being between the two, the market would be no impediment or annoyance to the station—rather than that the market should be placed elsewhere where railways would have to be specially brought to it.

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*Extracts from Evidence.*

Mr. J. Mitchell, Whitby, Ev. W. H. Pannell, p. 307: "The total value of our fisheries last year amounted to £45,000, and I may confidently say that one great reason why one half or even more does not come to London is the fear that exists of the block in the approaches to the market."

Mr. F. W. Leleu, Billingsgate, Ev. W. H. Pannell, p. 512: "*Q.* Do I take it from you that it would require 24 hours to unload the railway-borne fish and place it in a convenient place?—*A.* And reload it again.

"*Q.* That is your answer?—*A.* Yes."

## SCHEME.

It will also be seen by the PLAN, opposite page 490, that the South-Eastern Railway are connecting two parts of their system by a line from Bricklayers Arms to a spot on their present line between Cannon Street and Waterloo Junction. This would greatly facilitate traffic to the proposed market.

But even if any of the Railways should continue for a time to deliver fish to market by vans, we shall show that there would be abundant room for such vans to enter the market, unload, and leave without any delay.

Thus the means for "rapid and complete collection" are established as far as land-carried fish is concerned.

**Great advantages to sea-borne fish.**

But great as these advantages are, they are equalled or surpassed by those which this scheme offers to sea-borne fish. With respect to these it is proposed that a short branch line of a few hundred yards should be thrown out from the North Kent branch of the South-Eastern Railway

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### *Extracts from Evidence.*

Mr. J. Sims, Hull, Ev. W. H. Pannell, p. 30: "*Q.* Supposing we had a fish market some distance from Billingsgate, do you say you could bring 12,000 boxes annually?—*A.* No. 12,000 boxes in a week" [6 stone in a box].

Mr. Thomas W. Downing, Yarmouth, Ev. W. H. Pannell, p. 148: "There are hundreds of lasts—and there are 13,000 go to the last—of herrings, and we are obliged to salt them down, and send them to the Mediterranean markets. . . . I think the export trade from Yarmouth is more than 100,000 barrels per year.

"*Q.* Would a large quantity of them come to London, then, as fresh fish if there were better arrangements?—*A.* I should think 40,000 barrels of them would."

### SCHEME.

system, say from near Erith station to a landing stage at the river side, at which sea-borne fish could be landed. This is an easy matter, and has been done by a private firm of coal merchants for their business.

[NOTE.—Any objection to landing fish at Erith is met thus—Water-borne fish is landed at Harwich, and sent by train, so in fact is all land-borne fish; it all comes by water part of the way from the spot at which it is caught to some port, and thence by rail. It is therefore merely a question of different proportions of the two parts of the journey.]

The advantages of this arrangement would be—to the trade and the public the fish would arrive in the market from one hour to one hour and a half earlier than now, which in some cases would be equivalent to the gain of a day; to the captains of vessels a clear avoidance of

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### *Extracts from Evidence.*

Mr. R. Hewett, Billingsgate, Ev. W. H. Pannell, p. 481: "*Q.* Do you think that the rail-borne fish gets into market more quickly than the water-borne?—*A.* Yes; sometimes the water-borne fish has to be put out into a barge, and all sorts of difficulties."

Alderman Smethurst, Grimsby, Ev. W. H. Pannell, p. 333: "*Q.* Cod coming by water?—*A.* Yes, to Gravesend, . . . and then sent by boats.

"*Q.* How long are they coming up?—*A.* Leave at perhaps 12 o'clock at night, and up here at 4 o'clock in the morning."

[NOTE.—By this scheme (landing at Erith) they would be up from Gravesend in about one hour.]

the tedious and unpleasant navigation through the pool and a saving to the ship of from 3 to 4 hours or more in every voyage; and to the owners of carrying fleets an augmentation of the value of their property by enabling probably six vessels to do the work which now requires seven, perhaps even five to do the work of six.

This has always appeared one of the very important advantages of this scheme, and we feel safe in venturing an opinion that this arrangement alone—namely, the discharge of cargoes of fish arriving by water, at a point some 15 miles down the river—would of itself almost double the present supply; and in this we are supported by the authorities quoted by the *Daily Telegraph* of April 23rd, 1883: " . . such distinguished authorities as Mr. Spencer Walpole and Professor Huxley, who tell us that were it but possible for the cutters and steamers laden with fish to find a market further down the river which could be accessible to them at any hour of the day or night, the fish poured into the metropolis might be *doubled or trebled within 12 months.*"

**Immense gain by a landing-place down the river.**

N.B.—The S. E. Railway has now opened a pier in the

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### *Extracts from Evidence.*

Mr. J. Sims, Hull, Ev. W. H. Pannell, p. 53: "*Q.* Have you ever known of a steam cutter missing a market by not being able to get up to Billingsgate before 11 o'clock in the morning?—*A.* Oh yes."

Mr. R. Hewett, Billingsgate, Ev. W. H. Pannell, p. 483: "*Q.* Do you not come alongside (steamers to Billingsgate)? —*A.* No, and never have been as yet."

SCHEME.

Medway not far from the confluence of that river and the Thames, and the discharge of cargoes at that point might be found to effect a still greater saving of time.

Nevertheless, the market being on the river, the sea-borne fish could be landed at the market, if preferred, by means of floating platforms communicating with the sub-floor.

[NOTE.—"With respect to vessels passing under bridges, the vessels of Messrs. Hewett and others, which bring fish, are screw steamers of about 160 tons burden, and drawing 10 to 12 feet when laden; but screw steamers (belonging to Messrs. T. and C. Nichols) of 1000 to 1100 tons burden, and drawing 11 to 13 feet, pass under all the bridges up to and including Vauxhall." This information was kindly furnished by Messrs. T. and C. Nichols on August 6th, 1881.]

*Secondly: As to Rapid Trading.*

**Internal arrangements (see Plan).**

In the "PLAN" is shown how provision would be made for receiving railway trucks on to the floor of the market.

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*Extracts from Evidence.*

Mr. Joseph Morrell, Grimsby Ice Company, Ev. Spencer Walpole, p. 62: "*Q.* Will you inform the Inspector how many steamboats there are belonging to the various fleets running to the North Sea?—*A.* There are 4, 7, and 8.

"*Q.* What is the gross tonnage of these steamers?—*A.* About 113 tons clear of engine room."

Mr. Paul Storr, Market Clerk, Billingsgate, Ev. W. H. Pannell, p. 619: "All the steamers which came up to Billingsgate in 1880 were 396."

## SCHEME.

[NOTE.—The rails as proposed would accommodate two hundred and fifty trucks, and as a truck load per day is, roughly speaking, 1000 tons per year, there would be provision for 250,000 tons as an annual supply by rail alone; whereas the whole official return for 1880 is 130,629 tons.]

This note does not mean merely that twice the present supply would be the extent of accommodation the market would furnish, but that twice the present gross daily supply could be on show in railway trucks alone at one time. There would be plenty of lay-by room for the emptied trucks to be shunted and more brought up beside all the arrivals by other means, so that if the supply increased two, three, four, five or six times there would be plenty of room.

N.B.—Compare this with the extract from Mr. Hewett's evidence quoted below.

Also how provision would be made by platforms and their adjuncts for enabling buyers to see the entire railway supply in a few minutes.

Also how each truck as soon as it is run into the market would become a stall or shop, by the side of which wholesale trading might be carried on for the sale of its contents.

Also how facilities would be afforded by means of bridges

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### *Extracts from Evidence.*

Mr. R. Hewett, Billingsgate, Ev. W. H. Pannell, p. 481: "*Q.* Quotation: 'If only a twentieth part of the fish was taken off the vans at once, we should not be able to move one way or the other'?—*A.* Yes."

### SCHEME.

crossing the rails for the removal of fish from the trucks to any other part of the market.

### *Thirdly: As to Rapid and Complete Distribution.*

(See KEY PLAN, opposite page 507.)

**Position excellent for "*Distribution.*"**

The position of the market would be so advantageous as to render this point almost inexhaustible. But, firstly, it may be said that if a map of London be divided into two equal parts by a line running north and south, and the same be done by a line running east and west, the spot at which these two lines cross each other will be almost exactly that proposed for the market, and that, it is submitted, other conditions being met, is the natural position for a chief market, and especially a fish market.

Moreover, with respect to the railway system in direct connection with the market stations, it is proposed that an addition should be made of two small curved junctions, the one being from the South-Eastern line southward to the

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### *Extracts from Evidence.*

Mr. Alderman Smethurst, Grimsby, Ev. W. H. Pannell, p. 328: "I think Billingsgate does not compare with our place."

Mr. Samuel Ives, Billingsgate, Ev. W. H. Pannell, p. 457: "*Q.* Therefore in your judgment something like £40,000 per year might be saved in the portering and bobbing alone? —*A.* No doubt about it.—"*Q.* If there were plenty of convenience?—*A.* Yes."

Mr. J. Larkin, Cheapside, Ev. W. H. Pannell, p. 564: "*Q.* It costs you from £1 to £2 per day to get your fish off the salesman's stall to put in on your cart?—*A.* Yes."

## SCHEME.

South-Western across York Road, the other from the South-Eastern northward to the London, Chatham and Dover across Blackfriars Road.

With these two additions it will be seen by a glance at the District Railway map of London that with respect to the fishmongers and the public resident in the districts known as south-east, south-west, west, north-west, north, west central and east central, comprising about three-fourths of the population of the metropolis, the facilities afforded them may almost be spoken of as bringing the market to their own doors. And with respect to the remaining districts of the extreme north-east and east, it is only necessary for the junction now in progress between the Metropolitan and the Great Eastern systems at Liverpool Street to be completed to afford to them equal advantages. *So that a fishmonger who preferred to travel*

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## *Extracts from Evidence.*

Mr. J. White, Hastings, Ev. W. H. Pannell, p. 212: "*Q.* You want a central market?—*A.* Yes.

"*Q.* So that the public can get at it?—*A.* Yes, by thousands, the same as they do in Paris. In Paris it is like a fair."

Mr. E. Rice, Teignmouth, Ev. W. H. Pannell, p. 245: "I know enough (of London) to say that Billingsgate is at one end of the town.—*Q.* You think Billingsgate is not near the centre of London?—*A.* I do not think so."

Mr. E. Rice, Teignmouth, Ev. W. H. Pannell, p. 246: "*Q.* In London you see very little fish about?—*A.* Not like we do in the country."

### SCHEME.

*with his purchases by rail rather than by his own vehicle could be conveyed from the market station to any one of the* 170 *railway stations marked out upon the District Railway map of London within about* 30 *minutes. The enormous gain of such an arrangement is evident.*

If it is objected that fishmongers in London do not, as a rule, carry their purchases by rail, the answer simply is, "They have not had the opportunity conveniently." But fishmongers from towns 10 to 100 miles from London do so, and why should not those within the 10 miles embrace the advantage if provided?

River for traffic.

But, moreover, the river being a broad highway throughout the whole length of the metropolis, should afford large facilities for the floating means of locomotion to and from the market, and for this purpose it is suggested that special steam ferries should be fitted up, with extensive deck accommodation, to take costermongers' barrows and other small vehicles between the market and all piers throughout the Metropolitan District, say from Woolwich to Chelsea. This would be an immense gain in time, labour and convenience to the costermongers and

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### *Extracts from Evidence.*

Mr. R. Hewett, Billingsgate, Ev. W. H. Pannell, p. 474: "*Q.* Are you in favour of two markets?—*A.* Well, as regards that, I think you require more than two markets in London. You will recollect that London contains 244 square miles. It is hard for people to come to one particular market to buy fish. I think there should be several markets."

## SCHEME.

small distributors in the east of London, who are a large class and demand important consideration, and at the same time would reduce the street traffic in the vicinity of the market.

[NOTE.—These steam ferries would be especially useful in the matter of late deliveries, supposing (which is most probable) that telegraphic communication will be established between the market and certain stations on the river and otherwise about London, and the public apprised by flag signal that a special delivery of fish is on its way, and that the ferry will start for the market at a stated time. Costermongers and others with small vehicles could take ferry and be in the market when the fish arrived.]

Late deliveries made known throughout London while on the way.

Ice wells would of course form an important item in the "Scheme."

But, moreover, the map of London will show that the market would be peculiarly well situated with respect to the great road arteries of London. The Waterloo Road, which runs from the market itself, is the trunk line of all the system of roads and streets south of the Thames,

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## *Extracts from Evidence.*

Mr. Paul Storr, Clerk, Billingsgate Market, Ev. Spencer Walpole, p. 29: "It is in the mackerel and herring season that afternoon deliveries of fish mostly take place."

Mr. S. Alexander, Limavady, Ev. W. H. Pannell, p. 101: "The great bulk of our fish (salmon and eels) are delivered at Billingsgate in the afternoon, but they are re-iced and kept till the morning."

### SCHEME

and the great arteries running east and west on the north side of the river, namely the Embankment, the Strand, and Holborn, would be reached each in about its centre—a most fair division—in a few minutes; and from these main arteries the entire system of roads and streets throughout the map of London may fairly be said to spring.

Note on probable south embankment.

[NOTE.—It is difficult to believe that a work so transparently necessary as an embankment or road-way of some kind along the mud of the south shore from Blackfriars to Westminster Bridges, with communication to each, can be long delayed, and it will easily be seen how greatly the utility and beauty of such a work would be increased by the market, and also how, reciprocally, the market would be assisted by it. This is indicated in the Plans.]

Then as to cart traffic and accommodation. Those from the immense area of the W. and S. W. districts would travel over Westminster Bridge and the bridges farther

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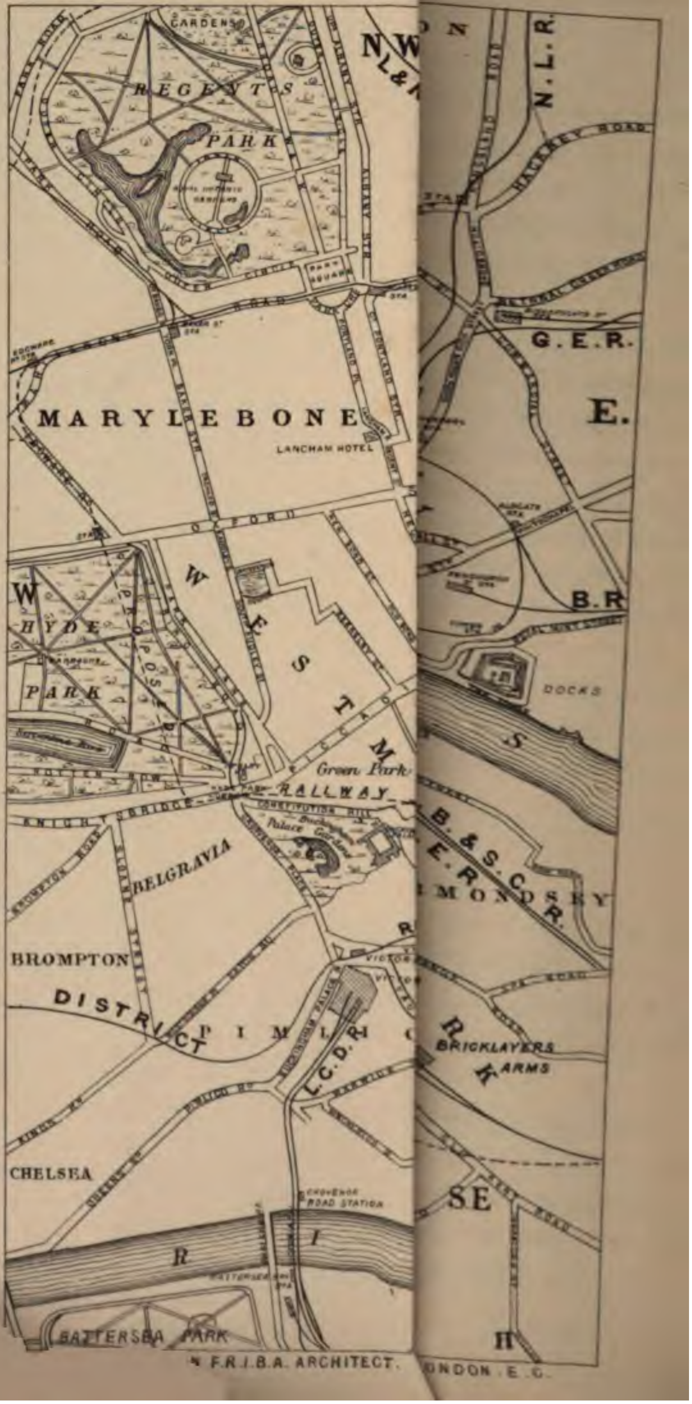
*Extracts from Evidence.*

Mr. W. Birt, Great Eastern Railway, Ev. W. H. Pannell, p. 375: "London is growing so fast that I believe the requirements could be far better served by the establishment of two or three additional markets than by any alteration which could be made to Billingsgate."

Mr. H. Lambert, Great Western Railway, Ev. W. H. Pannell, p. 315: "I have already stated that, looking at the present position of Billingsgate Market, if a new market is contemplated I think all interests would be better served by having one market in a more central site."

# SCHEME FOR DON.



F.R.I.B.A. ARCHITECT. NDON. E.C.

west; from West Central, over Waterloo Bridge; from E. C. and N., over Blackfriars, and from E., over London and Southwark Bridges. This applies also to railway vans, supposing their use must in any degree be continued. So that although at first glance it would appear that Waterloo Bridge must have an undue share of the vehicular traffic, yet upon examination its portion is seen to be no larger, but probably less, than that of any other of the metropolitan bridges.

The traffic of the south needs no explanation.

In fact, *the market might be said to be the nave of a wheel, the spokes of which are the roads from the various districts and railways of London.*

**Space for vehicles *in* the market.**

Then, as to internal accommodation for vehicles. The sub-floor would have an area nearly equal to that of the principal floor, namely, 191,250 square feet.

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### *Extracts from Evidence.*

Mr. Frederick Hogg, Bridlington, Ev. W. H. Pannell, p. 159: "Met the trawl men in our neighbourhood last Friday, and I asked them in the event of there being greater facilities for the disposal of fish here, would they send more; and they said if there were in London, they themselves would send all their fish to London. It represents in the cod-fishing season a weekly catch of 10,000 to 12,000 fish. *Q.* They would be content with 2½*d.* per lb.?—*A.* Yes, they would be glad to enter into a contract with you for nine months to come."

Mr. A. Ingram, Peterhead, Ev. W. H. Pannell, p. 186: "For one herring that is sold in Billingsgate Market or in London Market there are 100 sold in Glasgow."

## SCHEME.

Now let us estimate the space occupied by the three classes of vehicles using the market, averaging as under :—

| | ft. | | ft. | | sq. ft. |
|---|---|---|---|---|---|
| Railway vans, say . . . . . . | 25 | × | 8 | = | 200 |
| Carts, say . . . . . . . | 15 | × | 8 | = | 120 |
| Barrows, say . . . . . . . | 8 | × | 4 | = | 32 |

Then if we take—

| | sq. ft. | | sq. ft. |
|---|---|---|---|
| 100 railway vans at . . . . . . | 200 | = | 20,000 |
| 800 carts at . . . . . . . | 120 | = | 96,000 |
| 800 barrows at . . . . . . . | 32 | = | 25,600 |
| | | | 141,600 |

There is then left 50,000 square feet for pillars, staircases and moving room upon the sub-floor alone, and under cover. Thus provision is made for more vehicles in the

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### *Extracts from Evidence.*

Mr. Samuel Ives, Billingsgate, Ev. W. H. Pannell, p. 467: "Costermongers will not come to Billingsgate Market because they object to being driven and carted about by the policemen from pillar to post, consequently they go to other markets."

Mr. Samuel Ives, Billingsgate, Ev. W. H. Pannell: "*Q.* Does not a great deal of the block that occurs at Billingsgate Market arise in consequence of the quantity of carts coming from the outskirts of London to Billingsgate Market?—*A.* Simply the vans which bring the fish, the carts cannot approach the market anywhere."

[In this scheme both vans and carts would all be *in* the market.]

Mr. J. L. Sayer, Billingsgate, Ev. Spencer Walpole, p. 73: "And 1400 carts daily coming to our market."

market and on one floor than it is estimated block up the thoroughfares around Billingsgate at the present time. The railway vans would be taken up to the principal floor by hydraulics and placed between the railway trucks, or they could be unloaded and discharged at once and their contents sent up, or could be driven in on the principal floor if preferred, and thus the entire day's supply would be presented at one view to a buyer as soon as he entered the market.

**Railway vans**

But besides this there may be seen in the Plan large accessory spaces under the railway entrance and exit, and with these there is convenience shown for 3000 vehicles at one time under cover, and in the market and its

**3000 vehicles under cover.**

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*Extracts from Evidence.*

Mr. J. Larkin, Cheapside, Ev. W. H. Pannell, p. 563: "*Q.* You said you stood by the church at the bottom of Fish Street Hill. How long are you getting out from there? have you any difficulty in getting out?—*A.* Yes, very frequently.

"*Q.* How long?—*A.* I am over an hour and a half sometimes."

Mr. J. P. Knight, London, Brighton and South Coast Railway, Ev. W. H. Pannell, p. 552: "*Q.* If you take the Custom House down (merely that) and have it as a sort of lay-by for your vans, you would defeat your own object; the object is to get rid of the vans as soon as they come?—*A.* Yes."

[NOTE.—Why vans at all? Surely the object should be to get rid of such an obstruction altogether.]

accessories, without encroaching at all upon the area of th principal or actual trading floor of the market.

Taking all these means into consideration, it seems impossible that any spot in the whole area of London coul answer the requirements of the third condition more completely, namely "The rapid and complete distributio of the commodity to all parts of the community dependent upon it for supply, and that as nearly equally t all as possible."

### *Additional Advantages.*

There remain now to be noticed some few of the important advantages *incidental* to this scheme.

Condemned fish. Easy of detection and removal.

All fish could be officially examined in the trucks or vans as they arrived, and, if condemned, could be covered over and removed without being unpacked or exposed at all in the market. This is very important, because, as the Prime Warden says in his evidence before Mr. Spencer Walpole (page 4), "The difficulty which our meters have, of course, is, that the very early hour at which it is done, and the immense quantity of fish which pours into the market in a very short time, renders it almost (humanly speaking) impossible to watch every cart and every cargo of fish." [In this scheme the task would be easy, and escape from detection practically impossible.]

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### *Extracts from Evidence.*

Mr. J. Blackie, Leith, Ev. W. H. Pannell, p. 192: "I think there should be a retail market besides the wholesale market. Senders would try to send some fish to the retail market."

### SCHEME.

Market refuse easily cleared.

The market being over the river, all market refuse could be carried off through slides or shoots, down to barges placed below for the purpose, so that the market would be always clean and sweet, and no adjacent property could be injured by confined smell, as is said in evidence to have been the case at Liverpool.

Moreover, the market being 50 feet above high-water mark, and in open space, all smell would be effectually carried away by natural means, that is, by currents of air clear above the tops of surrounding buildings.

Retail market.

Public promenade.

A complaint was made in the evidence that whereas Billingsgate was, and is intended still to be, a market for the public as well as for the trade, it has long ceased to be so by its crowded state in the morning, and by being closed at 3 P.M. It is proposed to meet this want by a row of shops along the whole front edge of the market, facing the river outwards and the market inwards, and outside of these shops to throw out from the main structure a gallery 25 *feet wide for a public thoroughfare and promenade overlooking the river and Thames Embankment.* Arrangements are also shown in the Plan, upon the principal floor, in the space between the shops and the rails, for several rows of stalls, suitable for the class of dealers known as Bomarees; and this arrangement would complete the classification of the market into the three parts deemed necessary, namely, *wholesale, semi-wholesale, and retail.*

Three classes of market: "wholesale," "semi-wholesale" and "retail."

Benefits to public health.

Better market would undoubtedly increase the consump-

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*Extracts from Evidence.*

Mr. J. Blackie, Leith, Ev. W. H. Pannell, p. 194: "*Q.* And that the fish should be exposed for sale so soon as it arrives at the market?—*A.* Yes, and all day long."

### SCHEME.

tion of fish, the advantages of which, both economical and sanitary, to the population of London are self-evident.

**Increased employment to poor.**

Another highly valuable result would be that the increased demand would find employment for a number of the poorer inhabitants of fishing towns.

**Increased value to shore property.**

With respect to the space between the market and the wharves, it is proposed that that which is now mud during

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### *Extracts from Evidence.*

Mr. R. Mellish, Grimsby, Ev. W. H. Pannell, p. 9: "There is here a roker, a species of skate. I will undertake to say there is more virtue in that fish than there is in skate, and it all goes to Holland and Belgium."

Mr. James Barber, Mevagissey, Ev. W. H. Pannell, p. 234: "I should wish that pilchards should be introduced into London, because that is more particularly the staple industry of Cornwall. . . 12,000 to 13,000 hogsheads of pilchards have been cured last season, and they went to Italy. None of this fish touches the market here, which would be a great boon to the poorer classes."

Mr. H. Hornblower, Costermonger, Ev. W. H. Pannell, p. 630: "*Q.* Have you sold pilchards from the London market?—*A.* Yes, we generally sell them for fresh herrings, people do not know the difference."

Mr. R. Hewett, Billingsgate, Ev. W. H. Pannell, p. 477: "They (retail fishmongers) would have an opportunity of taking shops in those markets where they would get better accommodation than they get now as a rule."

Mr. A. Ingram, Peterhead, Ev. W. H. Pannell, p. 179: "Cod-fish in Peterhead, summer and winter, they would it 10*d.* each, weighing about 14 lbs."

SCHEME.

about ten hours of the day should be made [illegible] all times of tide by being excavated to the [illegible] and formed into a deep-water dock. The [illegible] to the wharfingers and owners of property [illegible] would be enormous, because the barges by [illegible] traffic is carried on could come alongside [illegible] wharves at any time, instead of, as now, [illegible] so much time in waiting for tides. This [illegible] compensate for any change of conditions [illegible] owners, resulting from the erection of the [illegible] would increase the value of the property at the [illegible] of existing arrangements.

As to fish brought to market alive in [illegible] tank trucks, which will probably be provided [illegible] to construct permanent salt-water tanks [illegible] tank trucks with the live fish in may be [illegible] the fish may be changed from the trucks to the [illegible] without being injured.

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## *Extracts from Evidence.*

Mr. C. W. Morris, Lowestoft, Ev. W. H. [illegible] "Cod and whiting can be kept [illegible] vessels. . . . The fish can be kept alive from day to day. You can keep them for weeks, and get them out as they are required for market."

Mr. J. Noble, Midland Railway, Ev. W. H. [illegible] p. 382: "*Q.* Has the idea ever crossed your mind of bringing fish alive to market in tanks? *A.* [illegible] be done, but done at a certain cost.

"*Q.* Are you aware it is done in [illegible] *A.* No, I do not know that."

## SCHEME.

In the early part of this schedule it is hinted that t scheme has important claims on the ground of ornam as well as on that of utility, and it is now submitt that from its magnitude, its position, its style, and accessories, it would add to London one of its ch attractions, and would, in fact, form the natural co plement and balance to the Thames Embankment.

We think, upon a review of this scheme, and a caref examination of the Plans, that its almost exhaustle advantages will be seen to fit it in a most fortuito and altogether extraordinary manner to meet all th requirements which the fish supply can demand. It believed capable of reforming and bringing up the trad to the standard of the present age, and moreover wi be equal to the demands even of an age to come whe London will have increased still more. At least it appea that the four chief evils complained of as resulting fro the present state of things, namely:—short supply; lat and difficult distribution; deteriorated quality; an monopoly prices—would give way to its influence, and i their places would be realised abundant supply; early an easy distribution; improved quality; and competition price

There is no reason why it should not enable every fishmonger in London and for 20 miles round to supply fish, cheaply and abundantly, to his customers for breakfast, and the benefit of this to the public health would be beyond all calculation, while the gain to those engaged in the trade would be equally great in the fact of being able to conduct their business with a rapidity, ease, and comfort which under the present state of things they have no opportunity of realising.

## [illegible]

We venture further to suggest [illegible] scheme, as much of the area which [illegible] the South-Eastern Railway [illegible] Thames, as is covered by small property [illegible] for further extension of a [illegible] future, feeling assured that [illegible] to the conviction to which [illegible] the promontory on the [illegible] one of the sides of the market [illegible] posed scheme we have [illegible] merely the best in London [illegible] only spot of which [illegible] purpose it is perfect in all [illegible] is "everywhere at once.

We have thus enumerated [illegible] our scheme, and we now beg [illegible] our judgment, the happy [illegible] markably perfect manner in which [illegible] shown to dovetail upon it have [illegible] of advantages which probably [illegible] upon any other spot in the metropolis [illegible]

Finally, we ask especial attention [illegible] sidering so very small an amount [illegible] required to be taken, the market [illegible] obtained for the mere cost of construction.

### Extracts from Evidence.

Mr. J. P. Knight, London, Brighton and [illegible] Rev. W. H. Pa[illegible] "In my opinion [illegible] that a fish market ought to [illegible] of London. [illegible] there. Why [illegible]

## PART III.

### STATISTICAL—FINANCIAL.

In estimating the financial prospects of this sche
are particularly fortunate in having a sound basis to
late from; for it must be remembered that it is n
amount of charges for market accommodation at Bi
gate—regarded as a necessary tax upon the commo
that is a source of complaint, but it is the small a
and imperfect character of the accommodation, an
extra tax and other evils resulting therefrom, wh
the real incubus of the trade. We shall therefore
our estimate upon the present reasonable and
sary charges, regarding the unnecessary as no lon
be taken into account when a larger market shall
operation.

Source of present complaint.

From the "Bye-laws, Rules, Orders, and Regulati
Billingsgate Market, 1876," still in force, we extra
following:—

Present market changes.

*The First Schedule.*

Tolls to be charged upon vessels laden with fish:—

| | s. |
|---|---|
| For every row boat with river fish . . . . . | 0 |
| , ,, vessel not exceeding 5 tons measurement . | 2 |
| ,, ,, ,, ,, ,, 10 ,, ,, . | 4 |
| ,, ,, ,, ,, ,, 20 ,, ,, . | 8 |
| ,, ,, ,, ,, ,, 35 ,, ,, . | 14 |
| ,, ,, ,, ,, ,, 50 ,, ,, . | 20 |
| ,, ,, ,, ,, ,, 75 ,, ,, . | 30 |
| ,, ,, ,, ,, ,, 100 ,, ,, . | 40 |
| Exceeding 100 tons, then for every ton and part of a ton | 0 |

ls to be charged upon vans, carts, and other vehicles
:n with fish :—

| | s. | d. |
|---|---|---|
| With 2 wheels, each | 1 | 6 |
| Exceeding 2 wheels, each | 2 | 6 |

'olls to be charged on fish brought into the market in other way,
er cwt., and for every fraction of a cwt., one penny

### The Second Schedule.

tallages to be charged in the market:—On the base-
ıt, at a rate of not exceeding two shillings and sixpence foot per annum for the open space.

### On the Ground Floor.

.t a rate calculated on the superficial area of each stall tanding of not exceeding ninepence per foot per week.

### On the Upper or First Floor.

.t a rate calculated on the superficial area of each stall tanding, of not exceeding twopence per foot per week.

'hese are the rates at which the present market pro-
:rs—that is, "the Corporation of the City of London"—
rge for the use of the market.

.et us see how this scale works out, as far as the gross ılts to the market providers is concerned, and also as far the trade and the consumers are concerned, regarding ·ket charges as a necessary tax upon the commodity.

'rom a Blue Book issued by the Corporation of the City .ondon, dated March 21, 1882, containing a "Tabulated tement of the Receipts and Payments of the City's Cash ing the last ten years," we extract the particulars of

Finance over four recent years.

income derived from Billingsgate Market for the y 1877, 1878, 1879, and 1880. We select these four y because the bye-laws upon which the present tariff of t &c., is based, are, as we have shown, dated 1876, and returns of supply are issued up to 1880. Therefore necessary information for our purpose is complete for term of years.

RECEIPTS.

| BILLINGSGATE. | 1877. | | | 1878. | | | 1879. | | | 1880. |
|---|---|---|---|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. | £ | s. | d. | £ |
| Rents and standings | 13,687 | 10 | 11 | 19,493 | 14 | 4 | 20,600 | 9 | 1 | 19,909 |
| Tolls . . . . | 4,521 | 0 | 11 | 4,928 | 7 | 7 | 4,754 | 9 | 7 | 4,612 |
| Other receipts . . | .. | | .. | 120 | 2 | 6 | 309 | 15 | 0 | 131 |
| Totals | 18,208 | 11 | 10 | 24,542 | 4 | 5 | 25,664 | 13 | 8 | 24,653 |

PAYMENTS.

| | 1877. | | | 1878. | | | 1879. | | | 1880. |
|---|---|---|---|---|---|---|---|---|---|---|
| Billingsgate Market | 4,362 | 9 | 1 | 4,591 | 9 | 3 | 9,100 | 16 | 5 | 8,288 |
| Billingsgate, interest on money borrowed . . | 7,200 | 0 | 0 | 10,167 | 12 | 7 | 10,787 | 5 | 0 | 10,295 |
| Totals | 11,562 | 9 | 1 | 14,759 | 1 | 10 | 19,888 | 1 | 5 | 18,583 |
| Profit to the Corporation . . | 6,646 | 2 | 9 | 9,783 | 2 | 7 | 5,776 | 12 | 3 | 6,070 |

This is the result to the market providers. Now le see the result as far as the commodity is concerned. course the foundation of this income is the supply, w from the official returns we find to be—

| | 1877. | 1878. | 1879. | 1880. |
|---|---|---|---|---|
| Tons . | 107,168 | 126,769 | 126,892 | 130,6 |

Market charges pro ratâ.

From this we find the gross charges per ton by the ma providers for market accommodation

| | 1877. | 1878. | 1880. |
|---|---|---|---|
| Per ton . | 3*s.* 4¾*d.* | 3*s.* 10½*d.* | [illegible] |

And the gross expenses *incurred by* the market providers—

| | 1877. | 1878. | 1879. | 1880. |
|---|---|---|---|---|
| Per ton . | 2*s.* 1⅜*d.* | 2*s.* 4*d.* | 3*s.* 1½*d.* | 2*s.* 10½*d.* |

The averages for the four years being—

| | *s.* | *d.* |
|---|---|---|
| Charges per ton . . . . . . . | 3 | 9½ |
| Expenses per ton . . . . . . | 2 | 7⅜ |

From this it is seen that the entire charge made by the market providers upon the commodity is 3*s.* 9½*d.* per ton, equal to 1*d.* upon 49 lbs. of fish.

**Market charges not excessive**

It is plain this cannot be an oppressive charge for market accommodation—of course it may in detail be unequal in its administration, but with that we have nothing to do here, except to note that such inequality, which undoubtedly does exist and is a grievance, arises solely out of the want of space.

**Other expenses oppressive.**

NOTE.—It must not be understood that this is the whole expense which the commodity has to bear in transfer through the market, or in what we will call "changing hands"—that is from the time it arrives at market the property of the seller, till it leaves market the property of the buyer, because, according to the evidence of numerous witnesses in the official inquiries, from which we have made extracts, there is a very large expense for porterage into and out of the market (over and above the cost of carriage and railway vans), which arises almost entirely out of the want of space and accommodation. In fact, the real complaint, repeated and insisted upon throughout the evidence, by catchers and senders, by carriers both by sea and rail, by owners, consignees, and

> sellers in the market (with few exceptions), and by retail dealers who attend the market as customers—is in unison to the effect that it is the want of space and accommodation in the market and its accessories which is the real night-mare of the trade. It sits upon, and cripples the operations of the trade in a twofold manner. Firstly, causing an immense expense in money, time, and labour to be wasted in the "changing hands" of the present supply. And secondly, actually and largely limiting the amount of that supply.

*This is the burden and wail of the evidence from beginning to end.*

Results both "to" and "of" larger market.

Now having shown that the present charges on the gross supply cannot be considered injurious to the trade or oppressive to the consumer, let us see what the prospective results of greater market facilities would be if based upon the same state of things as far as they are satisfactory, and an improved state in the respects in which they are not.

This would of course depend upon the answers to two questions:—

Firstly, Would an improvement in the market accommodation both meet the requirements of the present excess of demand and assist in developing what we have called the latent excess?

Secondly, Would a correspondingly increased supply be forthcoming?

In answer to both, we have quoted some important evidence in the foregoing pages, and these present but a selection from the mass given, and all in the affirmative.

But beside these very competent and valuable opinions let us take some facts. In the year 1880, 130,629 tons of fish were delivered at Billingsgate. This is the gross supply for the population of London (about 5,000,000), and of the home counties (about 3,000,000 more), 8,000,000 in all—or, taking off for infants and persons who do not eat fish, 25 per cent., there are 6,000,000 of people to be provided for.

**Present supply per person.**

Now, from the gross weight of fish delivered, we have to deduct the condemned fish; the fishmongers' losses, and the weight of shells, heads, bones, skins, fins, offal, and all that is not actual food, estimated upon sound practical authority at one-half (or by some at rather more). This leaves as actual food for the consumers say 65,000 tons per annum, equal to about *one ounce and one-twentieth per day for each person;* and deducting again the loss by cooking, it is a fair conclusion that the present supply is about *three-quarters of an ounce per day for each person.* It can scarcely be necessary, we think, to adduce any further argument to show that the natural demand would range from three or four to six times the present supply.

The second question, that of a corresponding increase in the supply, is receiving a large amount of attention, and with a better understanding of the subject of fish cultivation, in addition to the facts already given in evidence of large quantities of fish now caught which might be sent to the London market, there cannot be a doubt of the supply keeping pace with demand.

**Economy of larger market.**

Suppose, then, as an outcome of the inquiries now on foot upon the general subject of fish-supply, such improvements result in the cultivation, preservation, catching, and conveying, that the larger market should receive three times the present supply, and that the demand should progress in equal ratio; a very moderate supposition, and one whic some support from a competent practical authority.

Mr. George Stevenson, in evidence, says: "For su the vastness of London, that you cannot overdo us fish. So long as we lower the price, London will ta the fish, aye, twice and thrice the quantity of fish rece (Evidence before Spencer Walpole, Esq., 1881.) An pose that the increased accommodation in the new m should realise the result indicated in the evidence Samuel Ives (*ante*, page 502), that £40,000 per year be saved in portering and bobbing alone if there only plenty of market convenience.

Saving by larger market

[NOTE.—This appears a somewhat startling state but it is shown by another witness to be a c estimate. Mr. Thomas Rudkin, in evidence Spencer Walpole, Esq., page 94, says: "These men at Billingsgate have not room the same salesmen at the meat market. . . . The por of that meat costs something like three hal per hundredweight . . . . and the porterage o fish per hundredweight exceeds sixpence.

| | £ | s. |
|---|---|---|
| 6*d*. per cwt. on 130,629 tons is . . . . . | 65,314 | 10 |
| 1½*d* ,, ,, ,, . . . . . | 16,328 | 12 |
| Saving | £48,985 | 17 |

These figures therefore more than support the jud of the former witness.]

Financial effect to market users and providers.

Then the financial effects to the two parties conc namely, the market users and the market providers, be thus:

The commodity would change hands, or, in other the market users would get the commodity throug market at ***one-third the expense*** which they now have to bear, while the market provider would realise ***three times the sum total*** of the present receipts for rents, standings, and tolls.

**Advantages stall-holders**

NOTE.—Even this does not exhaust the advantages to the stall-holder, for the market-floor having more than eight times the area of Billingsgate to receive three times the supply, it is clear that the stall-holder can have nearly three times the space of now for the same gross price he now pays, or he can have the same space as now at one-third the gross price, and this does not at all interfere with the financial results stated above.

**Income.**

This represents an income of about £75,000 per annum to the new market from the ordinary sources, while the current expenses cannot be much, if at all, increased from the present.

The working expenses of Billingsgate for the four years under notice average £6,585 per year. Say they increased to £10,000 per year, there would then be £65,000 per annum for interest of money and profit.

The estimated cost of structure is £300,000, and of approaches £100,000; in all, £400,000, the interest upon which at £4 per cent. would be £16,000, leaving a clear profit of £49,000 per annum (12¼ per cent.), which presumably would assist a "reduction of rates."

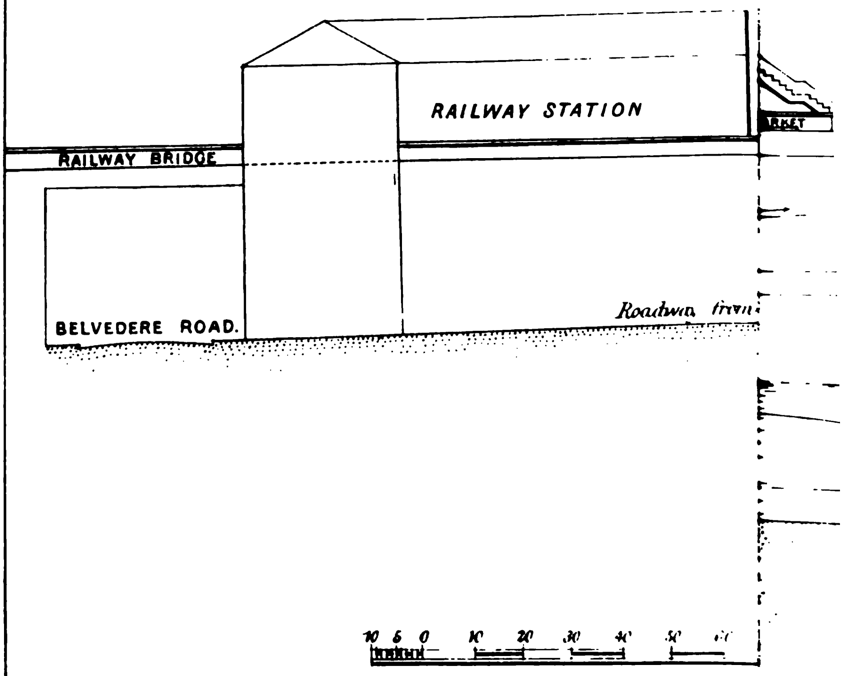
But in addition to this, there would be abundance of room in the market and accessories for ice-wells, curing-houses, store-houses for dried fish, and various other incidental purposes, all of which, being matters of detail, could be arranged according to the newest scientific methods which the International Fisheries Exhibition

will have brought to light, but which can be mad
sources of income.

It may also be thought just and expedient that as customers' carts, &c., would be accommodated under cover,
nominal charge should be made for police purposes, and t
assist in meeting current expenses.

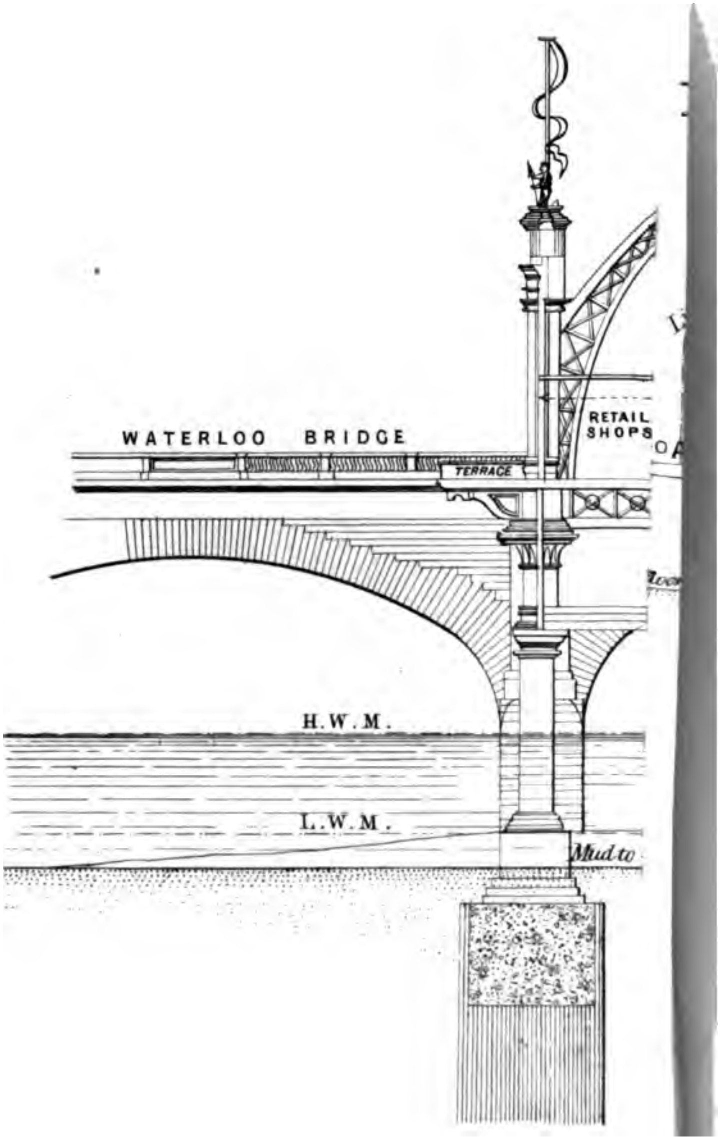
X.-II.

R



H.Bridgman. F.R.I.B.A. Architect.

X.–II.



*H.H. Bridgman, F.R.I.B.A. Architect.*

# THE
# EST APPLIANCES AND METHODS
# OF
# KING THE FORCE OF THE SEA
# AT THE
# TRANCE TO HARBOURS
# AND ELSEWHERE.

---

*O ARIS ET FOCIS.*—[W. ANDERSON SMITH.]

—E. 12.

# BEST METHODS OF BREAKING THE FORCE OF THE SEA.

IN dealing with great engineering constructions such as our more important breakwaters, only an engineer as a rule has any technical right to approach the subject; and were it merely a question of design and masonry I should not attempt to throw light upon the problem. But the subject of breakwaters is a wide one, and where it has been treated solely as a question of design and construction it has not unfrequently ended in failure, the first attempt at a harbour at Cherbourg and our own efforts at Wick being cases in point.

The success of the Plymouth breakwater commends its mode of construction for similar extensive undertakings, where a great outlay can be indulged in for a national purpose; and I do not propose to suggest improvements so much on the old lines in such cases as to point out a number of simple facts that, as a naturalist and a practical man accustomed to dealing with materials, appear to me might be profitably taken advantage of.

While seeking to cheapen the construction of greater sea barriers, I desire more especially to call attention to the simpler modes of protecting a fishing fleet, this appearing to me to be one of the most vital questions to the fisheries at the present time, seeing that a dozen small cheap bu secure harbours of refuge are of far greater importance t the fishing trade of our extensive coast than one grea central harbour, to which they may be unable to escape i an emergency. More especially is this a necessity in th west of Scotland, where no central harbour is possible, an where the gales are so severe, so frequent, and give so littl warning, that breakwaters must be numerous and local t be of any value.

The modes of dealing with a turbulent sea mus necessarily be as various as the conditions of the problen and the local requirements, and every case must b studied separately and considered on its own merits ; bu so far as generalisation will permit I divide the question a follows :—

I. SEAWARD. *At harbour mouths*, or to form harbours.

- A. *Vertical breakwaters from the bottom.*
- B. *Vertical breakwaters from the top.*
- C. *Horizontal breakwaters.*
  *Mooring anchors for above.*
- D. *Moles.*

II. SHOREWARD. *As direct and immediate breakwaters.*

- A. *Breastworks. Secured from undermining.*
- B. „ *To stand the shock of breakers.*
- C. „ *To prevent the removal of th coping.*

III. SHOREWARD. *As eventual breakwaters.*

- A. *To be filled up and completed by the sea itself.*
  *gradually extended and completed by man.*

### I.—A. *Vertical breakwaters from the bottom.*

The principle on which these have hitherto been started is that the sea will itself lay the loose stones, projected into it as a foundation, at the angle to form the least resistance, and thus the seaward face in the first instance is at as great an angle as the sea has been able to place the loose material opposed to it.

It is clear that the slope necessary to resist the sea washing upon loose newly placed material must be far greater than that requisite once the same material has settled and become solidified; and the *rapid fixing* of discharged material is of the first consideration in any attempt to check the roll of the breakers. Here is the first point at which it seems to me constructors may be greatly aided by using a power ready to their hands, and everywhere employed in our northern seas by Nature herself. The *Modiolæ*, or large horse mussels, exist in multitudes from just below low water of springs to a hundred fathoms,* and are so strongly attached by their powerful byssi that it is a matter of no small difficulty for a man to tear one of them from its hold. Not only is this byssus of great strength and tenacity, but it is very rapidly woven, and the creature has a habit of gathering about it everything within reach that will enable it to anchor itself. Were a few loads of these large mussels sunk on the seaward side of a growing breakwater as it progressed, they would soon tie the loose material together as securely as if the whole were cemented, and would thus enable progress to be made on a reliable foundation with greater speed and confidence.

Once such a breakwater had reached the surface at low water of springs, it should be covered with these *Modiolæ* until the whole was thoroughly tied together and had borne the brunt of the sea for a time. This breakwater would detain the heavier silt and gradually approximate to a natural sea barrier, until the whole quantity of material became almost a solid mass, on which the larger Fuci, such as palmatus, alaria, and saccharina, would flourish freely—palmatus preferably in the greatest rush and wash of water.

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* I have taken them at all depths down to one hundred fathoms off the Scottish coast.

Such a breakwater, if placed at a sufficient distance from the shore, would be sufficient to give security to a harbour without carrying it much above low water; and it could be raised at far less cost of material than if constructed without the aid of this natural binder.

If means were taken to have an abundant growth of the above-named larger tangles on the surface, the result would be still more satisfactory; for these large-leaved plants exhaust the breakers, and protect the boat in their lee, as any one can witness by dropping in behind fuci-covered rocks at half tide, when the breakers are found to be completely checked, and only the gentle roll of the waves encountered.

In erecting important breakwaters of stone of a substantial character, there appears to me to be one suggestion that would simplify and improve the ordinary mode of construction.

In place of manufacturing enormous blocks of concrete and conveying them at considerable cost to the required position, such blocks should be made over the point at which they are required to be deposited, and then lowered into their places so soon as they are solidified. It is very much easier to convey the materials for concrete than the manufactured blocks, especially when these reach weights or 1200 tons; and if heavy rough barges with ths were anchored in position in the lee of a temporary floating breakwater, as hereinafter described, the required blocks could be mixed on the water and dropped into place when ready. In this way blocks of a size and solidity capable of resisting the heaviest sea could be placed in position at a moderate cost by having the floating troughs removable, leaving the contained block supported from, and guided into place from, the encircling barges. It would be quite unnecessary that such troughs should be water-tight, as I have seen admirable concrete of Portland cement mixed under water, so long as the material was not allowed to escape: while the experience at Chatham Dockyard, according to Bernays, is, that "no cement sets better than such as is covered by the tide almost immediately after it is put into place." In any case the blocks are the better for being kept under water, and in the position we advocate this can be simply done.

Where the ground will permit of pile-driving by a steam hammer placed on a heavy raft, rows of piles may be driven to act as guides, over which rings of concrete could be dropped into position. In this manner a breakwater of even as great importance as that of Plymouth could be constructed on comparatively soft ground, by forming alternate rows of contiguous concrete pillars around the original wooden piles.

### I.—B. *Vertical breakwaters seaward—from the top.*

Submarine breakwaters must in all cases be matters of considerable labour and expense, and it has frequently suggested itself to many minds whether the waves could not be met and controlled *at the surface* by means of less costly and more simple constructions.

Great gates, swinging in the sea, have been proposed, against whose numerous spars the sea would exhaust itself;

while their non-rigidity in an elastic fluid enabled them to escape injury. These are not without utility. But while much may be said in favour of these, I think a more effective resistance may be afforded by the use of a system of vertical breaks, that could be readily applied in many localities where a safe roadstead for boats is a desideratum.

Take a quantity of young timber of (say) thirty to forty years' growth, and making about twenty feet length of tapering log when trimmed ; if these are loaded sufficiently at the thick end they will float vertically, with six or eight feet of the slender end above water. On this upper portion the branches may be cut off about eighteen inches from the trunk, so as to leave a strong simple projecting *cheveux de frise.* Each of these floating pillars swinging in the sea would break its force while yielding thereto, and a fisher community could readily construct a breakwater from them by their own labour. To form, say, one hundred yards of such a breakwater it would be advisable to have twenty heavier trees of perhaps a foot diameter at the water line. These should be anchored to large stones sunk to seaward, with a few stays on the landward side, and between each of these main trunks four of the loaded trees should be fixed at intervals. Each four would be secured together by strong spars, and side-boards to the other trees would prevent them driving sideways to their mutual injury.

It would be sufficient to drive a galvanised iron pin through the tree with a vertical eye at the landward side, through which a hook affixed to a galvanised strand No. 1 might be bent and secured. This strong galvanised iron strand rope would retain the several trees in position, and enable them to be readily detached and renewed when erloaded or waterlogged. Where there was much drift of seaweed, a buoyed rope with wooden spikes thrust through it along its course should be floated to seaward, on which the drift would be caught, but both rope and tree heads would require occasional looking to. This class of breakwater might be constructed on rough coasts where there is the usual growth of timber, at a very trifling cost. Spruce trees, although somewhat brittle as wood, stand the water fairly, and would suit sufficiently, while their small cost is a consideration. I estimate the cost of a construction of this character to a fisher community at £1 a yard, and this would quite cover the cost throughout a great part of the wooded districts of the country, where spruce timber can be had cheaply.

Although such an erection would not supply all the advantages of a stone-built sea breakwater, it would prove of great utility, and by attaching thereto the network floating breakwater suggested on page 535 complete security for fishing boats would be cheaply provided.

### I.—C. *Horizontal floating breakwaters.*

So much attention has been of late directed to the utility of oil as a floating or "horizontal breakwater," that I will not presume to offer any novel facts in this direction, but will rather seek to call attention to other floating breakwaters, and endeavour to throw some light on the principle that should underlie and guide other similar efforts.

In Thomson's 'Central Africa' we find a fact recorded that has frequently been noticed to a greater or less degree by other observers. "On Lake Tanganyika Mr. Hore drew my attention to the effect of the broad patches of green vegetable scum floating on the water, producing a smooth surface and causing the swell to pass quietly under the canoe without breaking, having thus the same effect as oil on the water." This allusion to the efficiency of a floating growth of small surface algæ or confervæ; the well-known shelter at a boat landing of the long floating fronds of seaweed, such as *Fucus nodosus;* and in deeper water the breakwater provided by a luxuriant growth of *Fucus palmatus* or other tangle, all point to the same principle. Clearly the principle to be educed from these and similar natural breakwaters is that of a multitude of yielding obstructives, or one great homogeneous yielding obstructive; upon which the force of the sea is spent.

I would propose to utilise such seaweed as *Fucus nodosus* or bladder wrack, by growing it upon light strong wooden hurdles, these hurdles to be thereafter anchored seawards in a row, so as to form a simple breakwater where it is desirable to protect a stretch of embankment against the full force of the sea, and under other similar conditions. The effect of the well-grown fronds of this seaware growing upon hurdles six feet across would be sufficient to break the rush of a considerable sea, as I have frequently proved.

But for a more exposed coast I would prefer to see an experiment made with an artificial surface-growth, formed by a multitude of small wooden dice linked together like artificial leaves, which would act as if it were a leaved plant, and could be simply constructed and readily placed. Wooden dice of the size required could be procured at very small cost, as made from the refuse of the woodyards, and joined together with wire rings at the corners. The whole should then be run through a pitch mixture, which would protect both the metal and the wood from the action of the sea, the breakwater being annually removed and redipped, in portions, if necessary. This artificial leafage floating on the water would, if sufficiently wide, protect all to leeward of it, and if combined with the perpendicular weighted breakwater previously described, the rush of a heavy sea would be little felt within a twenty-yard protection. The wooden dice should be about two inches square, and of the lightest material, one-fourth, or even one-eighth inch, being quite as useful for the purpose as inch flooring would be, so long as the floating power was sufficient to carry the metal joinings. This simple construction is especially fitted for boat harbours, as easily conveyed, easily constructed, and most effective even on the roughest coast.

Of all floating breakwaters, however, I prefer one more costly than any I have noticed, to which my attention was first directed on the occasion of the gales of recent years. During the height of the great and disastrous gale of November 1881, several large boxes containing young French oysters were torn from their seaward fixings and carried off by the sea. The boxes consisted of shallow wooden frameworks, with bottoms of ¼-in.-mesh galvanised wire netting. The sea was very rough indeed, and the boxes laboured heavily through the water, but I remarked that the small oysters, although almost light enough to float of themselves, yet were not washed out of the boxes, inside which the sea seemed only to rise peacefully, the wire netting permitting the *water* but not the *wave* to pass, as wire gauze keeps out gas, but not air. The upper edge of the boxes alone was visible, and they were too heavy to rise on the waves, being three yards by one, but the netting apparently passed on the wave as effectually as so much oil would have done. I have since frequently observed the effect of this floating netting, and have no doubt as to its efficiency when attached to a yielding framework. Such netting, however, ought to be carefully tarred, as this is even a better protection from the sea tha galvanising, and can be annually renewed. If lengths o this netting were affixed to a heavy wooden framewor floating in the sea, I am satisfied that no ordinary sea coul pass through fifty yards of it without having all dange removed.

Strong galvanised and tarred iron sheep netting of fou inch mesh and No. 13 wire, in lengths of fifty yards, coul be readily fixed on floating planks by means of ordinar staples, in such a manner that any portion could be lifte and renewed with facility. The planking, by intercrossin between the various lengths, would form the whole into a homogeneous float of a permanent character. Apart from anchoring towers seaward—which might be necessary—the cost of such a floating breakwater of 1700 yards by 10 yards wide, would not be more than £10,000, and would protect as great an area as the Plymouth breakwater, which cost a million and a half (£1,500,000) and took 28 years to construct, while as many days would construct the network breakwater.

Boat harbours of inferior capacity could be protected at a comparatively small cost.

Since I commenced this paper I have observed that Dr. McCosh would apply a somewhat similar principle to floating harbours of refuge—his network being of coir rope and india-rubber tubing, the meshes nine-inch square. I do not like the materials proposed, coir in my experience having little flotation, and india-rubber soon corroding in sea water, while the smaller the mesh the more effectual the breakwater ; yet the principle proposed by Dr. McCosh, I understand, twenty-five years ago, is so distinct that it appears to me remarkable that no effort has been made to effect to it even on a small scale.

And here I may add that the system can be simply, cheaply, and thoroughly tested on a sufficient scale at any herring fishing station where a supply of second-hand nets is available. These, spread over floating hurdles of two-inch scantling, although perhaps not so effective as my proposed wire netting, would, nevertheless, give the principle involved a very fair practical test, which it has not yet had on a sufficient scale.

As my desire is more especially to obtain, at small expenditure, good, safe boat harbours for our fishing craft, I wish particularly to call attention to the use of old herring nets for this purpose, as they are of little monetary value otherwise, are in sufficient plenty, and can be readily applied by the men themselves. In most fishing villages there are large iron boilers for the purpose of boiling down herring garbage for oil, or barking nets, &c., and if the old herring nets were thoroughly saturated with boiled herring oil, they would not only keep much longer in the water, but would at the same time continue to exude small quantities of oil that would remain between the meshes, and act as a further agent in the formation of a most effective breakwater, either alone or in combination with the perpendicular breakwater suggested on page 532.

From Hebraic history down through Aristotle and Pliny come frequent references to the value of oil as a breakwater, individual mariners in all times having made use of it in extremity, and I do not consider it necessary, in face of recent experiments, to enter upon the further consideration of what is of well-attested value. I only wish to draw attention to the mode of applying it noted above, as more lasting, more useful, and more reliable than its direct application alone.

### *Mooring Anchors.*

In securing these floating breakwaters, of any kind, the mode of anchoring or mooring would be of primary importance.

Where the ground was hard and the construction of moderate size, heavy stones or concrete blocks should be used, to which to attach the mooring chains by a ring, or the customary heavy cast-iron mooring anchors could be employed.

Where the ground was of a muddy character I would suggest the use of heavy cast-iron anchors with a screw flange—something in form like a large screw-nail ; these to be screwed into position by means of a long powerful iron-shod screw-pole with cross-bars, the mooring chain passing up the pole and retaining it in position until the screw was home.

In the case of more important floating structures it might be necessary to erect a few anchoring towers seaward, somewhat like miniature lighthouses or beacons, with cast-iron finishing columns. But the advantage of the anchor being placed where the power of the wave is least, points to the utility as moorings of large concrete blocks sunk to the bottom. And when the moorings must be on both sides, and the strain is thus only in one direction upon an anchor, there need be no difficulty in mooring any breakwater sufficiently.

### I.—D. *Moles.*

Where the ground is suitable I do not suppose a more satisfactory mole or jetty can be constructed than one of piles, on the old time-honoured principle of alternate rows, against and amongst which the waves are broken. The satisfactory result of such piles can be seen any rough day on the leeward side of a wooden pier; and now that piles of seventy feet long and upwards can be driven with facility by means of the steam hammer, the cost of such protective jetties ought to be very moderate. At the same time they could be advanced from the shore with a rapidity which would far outstrip any construction of stone. A pile of seventy feet long, with a hold of thirty feet in the ground and ten feet above high water, allowing for eighteen feet rise and fall of the tide at springs, would give twelve feet of depth alongside at any state of the tide. Several alternate rows of eighteen-inch piles, bound together at top so as to form supporting triangles, would carry a heavy superstructure and break a heavy sea.

### II.—*Shoreward.* As direct and immediate breakwaters.

#### A. *Breastworks secured from undermining.*

Where there is a rocky foundation to spring from, a solid bed is easily obtained; but with a shifting foundation of gravel, sand, or mud the difficulty is distinct. The advantage of piles in such a case is unquestionable, even if they be only driven in front of a concrete foundation. They are, however, more detrimental than useful where there is a loose backing and a stream of water, as they then rather facilitate the carrying away of the silt, and consequent undermining.

It is observable that shore breastworks most frequently give way through inattention to the foundation seaward, the builder starting too far inshore, and too directly, in place of smoothly causeying a slope up to the true foundation, so as to make a rise of one foot in two at the most, of sufficient height to break the force of the waves.

If the top of the water travels much faster than the bottom a line of dangerous breakers are formed, but if the bottom meets no serious obstruction and consequent friction, the whole body of water is led smoothly up an inclined pathway, to expend its force in a struggle with gravitation, in place of being flung bodily against the stonework.

### II.—B. *Breastworks to stand the shock of breakers.*

The advantage of well-made concrete in building shoreward breakwaters is evident from the smoothness of the face it may be made to present to the waves. If these find the smallest inlet they gradually increase its size, until the friction of particles causes a serious denudation to take place and rapid weakening of the structure.

There are many systems of interlocking masonry employed, from those used in the Eddystone Lighthouse, to the rows of contiguous columns with the intervening spaces built up. Their comparative advantages are matters of opinion; but that the strength and value of circular erections is great admits of no question, even when formed of comparatively weak materials.

A tidal harbour on a muddy, sandy, or gravelly coast can be protected by means of a very simple breakwater, which I have found capable of withstanding the heaviest seas of these recent winters, when more substantial breakwaters in the vicinity were swept away. This consisted of a circle formed of a number of young trees used as stakes, and driven a few feet into the ground at lowest water of springs. The whole was then wattled well together so as to form a sort of gabion. Into this a few boat-loads of stones were tumbled, and as the stakes were driven at a slight angle inward, it became a huge basket or gabion, with five or six feet of mud or sand, and a foot or two of stones on top. The waves are dissipated among the basketwork without seriously incommoding it; and some that we erected of 20 feet diameter have stood the severe gales of the last three winters in an exposed situation on a western sea loch, uninjured.

A waved line of such erections, raised at a cost of £5 each, would thoroughly protect a large area.

### II.—C. *Breastworks, to prevent the removal of the coping.*

Nothing so frequently happens to a shoreward breast as to have the coping carried off during some higher and more violent rush of water than usual. Arrangements must not only be made to carry the attacking water up a slope to the summit, but also for receiving it properly when it reaches higher than usual.

The consequence of the lack of such preparation is, that a heavy gale and high tide throws hundreds of tons, perhaps, over the top, to be sucked back, or to rush back with such violence as to carry the coping, and perhaps a slice of the wall along with it. By gradually curving the stonework *outwards* from the furthest point, the wave is curled back upon itself when it reaches the top, in place of being thrown over the breast.

### III.—SHOREWARD. As eventual breakwaters.

#### A. *To be filled up and completed by the sea itself.*

There is frequently considerable difficulty presented by shifting gravel beds on the foreshores, the sea driving them hither and thither, often to the destruction of neighbouring land and the removal of landmarks, as well as to the filling up of waterways. This can occasionally be met by driving a few rows of stakes deeper and deeper as you progress seaward. The sea soon throws up the gravel so as to fill up the spaces between the rows, making solid gravel beds which are themselves sufficient to stay the progress of the shifting stones.

But if when the beds are completed by the sea, a few boat-loads of common mussels, *Mytilus edulis*, are thrown on the seaward banks, they will within twenty-four hours securely anchor themselves, and bind together the whole bed into one solid immovable bank. Even the most shifty sands are secured in this fashion, and the heavy gales of the last season, which have been washing away the sandy gravel banks in our vicinity, have not disturbed the mussel-covered portion. On the great shifting, muddy, and sandy bay of Lochindaal, in Islay, mussels may be seen in little pyramids securely anchored, fixing the only reliable portion of the sea bottom, and securing the settlement of the sand about them.

And when upon this subject of the great utility of mussels as a binder for shifting ground, we desire to call attention to their importance as a means of keeping enemies, such as the teredos, at bay. When these sea-borers are troublesome, and the sea not too violent, a plentiful crop of mussels would keep them greatly at a distance, spreading over the stonework or woodwork that would otherwise be attacked by the teredos. Where wooden piers are the objects to be protected, the mussels can be hung around them in old nets until they attach themselves, when they will rapidly spread. Where stone breasts are to be protected, the mussels have only to be thrown down at the bottom before February, when they throw spat, and they will soon cover the walls as high up as they can manage to exist. They will then not only keep other dangerous life at a distance, but offer an important protection of themselves to the action of the waves.

The use of natural assistants is too frequently neglected when difficulties arise, and the shifting mud of many shallow bays can be readily fixed by planting *Zostera marina.* Bays over which it is impossible to walk at low water of spring tides, owing to sinking up to the thighs in soft mud, yet grow this sea grass plentifully, and so preserve the stability of their muddy bottoms.

### III.—B. *Shoreward breastworks, to be gradually extended and completed by man.*

On many parts of our coast the fishermen are obliged to procure stone ballast every time they go to sea, and on their return this is thrown overboard, frequently in a most careless and detrimental manner, in order that their open boats may be beached. By a little combination and at trifling cost a small mole to act as a breakwater could be marked off, by sinking large gabions full of gravel, with a twenty-foot young birch tree fixed in the centre. These rods should be fined away so as to offer little resistance to the sea, and when this is done they will stand the rush of a heavy sea for a lengthened period, as I have often been surprised to find.

The ground being thus marked off, the men on their return from the fishing grounds should be obliged to empty their ballast within these bounds; and in an industrious fishing quarter it would take but a short time before the mole would rise sufficiently high to give most useful protection. The use of horse-mussels seaward, and as it nears the surface, would bind it effectually, and form an artificia protecting reef of a natural character. During the construction of the Plymouth breakwater, vessels took shelte behind it so soon as a portion began to appear at lo water.

I have by no means sought to exhaust a great and important subject, but merely to add my suggestions to th general fund of information, looking mainly to supplyin such hints as would enable a fishing community, that wa really in earnest, to protect its own boats or render valuabl personal services to the Government, or those landowner who might initiate the undertaking, and point out the bes means of conducting it.

By simple means, local enterprise, and the use of natural assistants, much might be done to render a recurrence o the fearful disasters of recent years impossible, or at least improbable, to ordinary human foresight.

The depths or breadths of such floating breakwaters are o necessity merely approximate, and entirely dependent upon the position of the coast to be protected. If during great storms in the Atlantic the lengths of the waves are sometimes 600 feet, and the depth of disturbance is equal to the length of the wave, a coast exposed at any time to such a wave could not be protected by 100 yards of network. But such a wave would require 100 fathoms of depth, and could not retain its length within the 100 fathom line ; so that in all probability the longest wave that could reach our shores would be broken by 100 yards of wire netting.

In the shallow German Ocean, of an average depth of 600 feet, the length of the wave is not so serious as its rapid rise and turbulence, and I believe 50 yards of netting would break the force of its ordinary storms.

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